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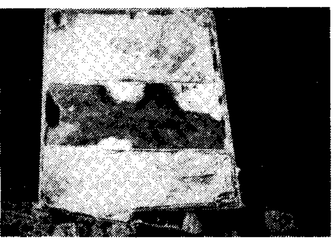

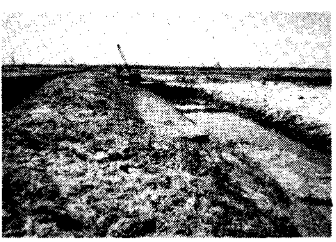

MISCELLANEOUS PAPER EL-90-10

CRANEY ISLAND DISPOSAL AREA

SITE OPERATIONS AND MONITORING REPORT, 1980-1987

by

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July 1990
Final Report

Approved for Public Release; Distribution Unlimited

Prepared for US Army Engineer District, Norfolk
Norfolk, Virginia 23510-1096

Unclassified

SECURITY CLASSIFICATION OF THIS PAGE

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1a. REPORT SECURITY CLASSIFICATION Unclassified	1b. RESTRICTIVE MARKINGS
2a. SECURITY CLASSIFICATION AUTHORITY 2b. DECLASSIFICATION / DOWNGRADING SCHEDULE	3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for public release; distribution unlimited.
4. PERFORMING ORGANIZATION REPORT NUMBER(S) Miscellaneous Paper EL-90-10	5. MONITORING ORGANIZATION REPORT NUMBER(S)
6a. NAME OF PERFORMING ORGANIZATION USAEWES Environmental Laboratory 6b. OFFICE SYMBOL (If applicable)	7a. NAME OF MONITORING ORGANIZATION
6c. ADDRESS (City, State, and ZIP Code) 3909 Halls Ferry Road Vicksburg, MS 39180-6199	7b. ADDRESS (City, State, and ZIP Code)
8a. NAME OF FUNDING / SPONSORING ORGANIZATION USAED, Norfolk 8b. OFFICE SYMBOL (If applicable)	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER
8c. ADDRESS (City, State, and ZIP Code) Norfolk, Virginia 23510-1096	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. / PROJECT NO. / TASK NO. / WORK UNIT ACCESSION NO.

11. TITLE (Include Security Classification)

Craney Island Disposal Area; Site Operations and Monitoring Report, 1980-1987

12. PERSONAL AUTHOR(S)

Palermo, Michael R.; Schaefer, Thomas E.

13a. TYPE OF REPORT	13b. TIME COVERED	14. DATE OF REPORT (Year, Month, Day)	15. PAGE COUNT
Final report	FROM ______ TO ______	July 1990	86

16. SUPPLEMENTARY NOTATION

Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)
FIELD	GROUP	SUB-GROUP	See reverse.

19. ABSTRACT (Continue on reverse if necessary and identify by block number)

The Craney Island disposal area is a 2,500-acre confined dredged material disposal facility located near Norfolk, VA. In 1981, the Craney Island Management Plan (CIMP) was developed to extend the useful life of the site for disposal of maintenance material from the project area. The CIMP called for subdivision of the site into three subcontainments and use of alternating filling and dewatering cycles. Management of the site in general accordance with the CIMP was implemented in 1984.

This report documents site operations and monitoring data for the Craney Island disposal area from October 1980 to September 1987. Field sampling operations, laboratory testing, and monitoring and survey data are described and interpreted. Updated projections of filling rates are presented.

(Continued)

20. DISTRIBUTION / AVAILABILITY OF ABSTRACT ☒ UNCLASSIFIED/UNLIMITED ☐ SAME AS RPT. ☐ DTIC USERS	21. ABSTRACT SECURITY CLASSIFICATION Unclassified
22a. NAME OF RESPONSIBLE INDIVIDUAL	22b. TELEPHONE (Include Area Code) / 22c. OFFICE SYMBOL

18. SUBJECT TERMS (Continued).

Confined disposal facilities
Consolidation
Desiccation
Dredged material
Dredged material disposal
Management
Monitoring
Water quality

19. ABSTRACT (Continued).

Based on the monitoring data collected to date and projections of future fill rates, the site will be filled to elevation +30 ft during FY 2000 if the present intensity of management is continued. If the site had not been subdivided and management for dewatering not initiated, the site would fill during FY 1997. Therefore, the CIMP as implemented to date will result in a gain in useful life of approximately 3 years or 25 percent of the remaining capacity. This benefit is less than the maximum possible benefit anticipated in the CIMP. The differences are due to a combination of factors, including inaccuracies of models in projecting long-term fill rates, inefficiencies in implementing the CIMP, natural inefficiencies of desiccation processes, and the placement of significant volumes of new work material in the site.

PREFACE

This report describes site operations and monitoring data for the Craney Island disposal area near Norfolk, VA. This work was conducted by the US Army Engineer District, Norfolk, and the Environmental Laboratory (EL) of the US Army Engineer Waterways Experiment Station (WES). Funding for WES was provided by the Norfolk District under Intra-Army Order for Reimbursable Services No. CA-88-3011, 12 February 1988. The Norfolk District Project Manager for the study was Mr. Tom Szelest.

This report was prepared by Dr. Michael R. Palermo, Research Projects Group, Environmental Engineering Division (EED), EL, and Mr. Thomas E. Schaefer, Water Resources Engineering Group (WREG), EED. Appendix E of this report was prepared by Mr. Gary F. Goforth, University of Florida, who was employed under an Intergovernmental Personnel Act agreement. Field monitoring activities and laboratory analyses described in the report were conducted by the Norfolk District. Technical review of this report was provided by Dr. Marian E. Poindexter-Rollings and Mr. Donald F. Hayes, WREG, and Mr. Szelest. The report was edited by Ms. Jessica S. Ruff of the WES Information Technology Laboratory.

This study was conducted under the direct supervision of Dr. Raymond L. Montgomery, Chief, EED, and under the general supervision of Dr. John Harrison, Chief, EL.

Commander and Director of WES was COL Larry B. Fulton, EN. Technical Director was Dr. Robert W. Whalin.

This report should be cited as follows:

Palermo, Michael R., and Schaefer, Thomas E. 1990. "Craney Island Disposal Area; Site Operations and Monitoring Report, 1980-1987," Miscellaneous Paper EL-90-10, US Army Engineer Waterways Experiment Station, Vicksburg, MS.

CONTENTS

CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
acres	4,046.873	square metres
feet	0.3048	metres
cubic feet	0.02831685	cubic metres
cubic yards	0.7645549	cubic metres
inches	2.54	centimetres
tons (force) per square foot	95.76052	kilopascals
tons (2,000 pounds, mass)	907.1847	kilograms

CRANEY ISLAND DISPOSAL AREA

SITE OPERATIONS AND MONITORING REPORT; 1980-1987

PART I: INTRODUCTION

Background

1. The Craney Island disposal area is a 2,500-acre* confined dredged material disposal facility located near Norfolk, VA (Figure 1). Craney Island is the disposal site for dredged material from the Hampton Roads area, to include the Federal channels for Norfolk Harbor and associated permit projects. The site was initially constructed in the mid-1950s and has since been in continuous use. A plan drawing showing the layout and other major features of the site is presented as Figure 2.

2. In 1981, the Craney Island Management Plan (CIMP) was developed by the US Army Engineer Waterways Experiment Station (WES) to extend the useful life of the site for disposal of maintenance material from the project area (Palermo, Shields, and Hayes 1981). The goals of the CIMP included maximization of storage capacity, dewatering and densification of dredged material, and maintenance of acceptable water quality of effluent.

Summary of Management Approach

3. The basic management approach recommended in the CIMP is as follows:

   a. Divide the site into three subcontainments by completion of cross dikes.

   b. Alternate disposal among the subcontainments on a yearly basis, allowing for a 1-year active filling cycle followed by a 2-year dewatering cycle for each subcontainment.

   c. Maintain ponded water during the active filling cycle to ensure acceptable water quality of effluent.

   d. Remove surface water, prevent ponding, and construct surface trenching systems to promote drainage and desiccation during the dewatering cycle.

4. Subdivision dikes were completed at Craney Island in October 1984.

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* A table of factors for converting non-SI units of measurement to SI (metric) units is presented on page 3.

Since that time the management approach as recommended in the CIMP has been generally implemented. However, the alternation of active filling between the subcontainments on a strictly annual basis and timely completion of surface trenching systems has proven difficult. Also, material from the ongoing deepening of Norfolk Harbor has been placed in the site.

Purpose and Scope

5. The purpose of this report is to document site operations and monitoring data for the Craney Island disposal area from October 1980 to September 1987. Field sampling operations, laboratory testing, and monitoring and survey data are described and interpreted. Updated projections of filling rates are presented. Recommendations on management approaches and monitoring activities are given. This report also serves as a format for future monitoring reports as more data are collected.

PART II: SITE OPERATION AND MANAGEMENT

Dike Construction and Upgrading

Retaining dike upgrading

6. During the period 1980 to 1987, the main retaining dike was periodically upgraded using the same techniques as in past years. Coarse-grained material was trucked from the east dike area for use in building up the west dike. Dewatered dredged material was used to the extent possible where placement by dragline was practical.

Cross dike construction and upgrading

7. The cross dikes were completed in October 1984 under an accelerated construction program that used a geotechnical fabric for the initial placement of material in the dike cross section. This construction technique enabled the dike to be completed quickly but resulted in wide dike cross sections (up to several hundred feet) at the base. Even with the fabric, some mud wave problems have occurred as the dikes were raised. The cross dikes are raised by trucking primarily coarse material from the east dike for placement.

Weir construction

8. In conjunction with dike upgrading on the west side, new weir structures were constructed (five were completed by July 1984; the sixth by September 1987). These weirs are located in the west corners of each subcontainment, as shown in Figure 2. The weirs are of the rectangular design and have a total weir length of 80 ft each, divided into bays of 6 ft each. The weir construction required that fill material be placed in the corners of the subcontainments to displace the soft dredged material. An excavation was then made in the fills to construct the weirs. During the fill placement, mud waves developed in front of the weirs, and the excavation could not be maintained to the desired depth. During the constructibility review of the design, invert elevations were changed to reduce cost and to aid in construction of the weirs. Invert elevation for weirs 1, 4, and 6 is +10.0 ft mlw, and invert elevation for weirs 2 and 3 is +13.0 ft mlw. The higher invert locations and the presence of the mud waves prevented effective drainage until the fill height was raised by later disposal operations.

Site Operations

Sources of dredged material

9. Sources of dredged material placed into Craney Island have remained generally unchanged since 1980. An updated log of the disposal history is presented in Appendix A. As in the past, the dredged material entering the site is principally maintenance material from the Norfolk Harbor channels, with some new work material from periodic channel deepenings and widenings (primarily silts and clays).

Disposed volumes

10. The volume of in situ channel material disposed in the site from 1980 to 1987 has varied significantly on a yearly basis. The average in situ volume dredged during this period was approximately 4.6 million cubic yards, which includes a low-volume year of 0.9 million cubic yards in 1981. If this low-volume year is not considered, the average volume placed in the site is 5.1 million cubic yards per year.

Dredged material placement

11. Following completion of the cross dikes, the rotation of disposal has generally been alternated between the subcontainments. The placement of the volumes from individual contracts in respective subcontainments is indicated in the disposal history in Appendix A. Major portions of the disposed volumes were placed in the north, center, and south subcontainments during fiscal years (FY) 85, 86, and 87, respectively. However, dredged material placement has not been completely confined to one subcontainment during any fiscal year since completion of the cross dikes.

Dredged Material Management

Ponding for filling cycles

12. Ponding of water in the subcontainments during filling cycles has been accomplished routinely and has resulted in acceptable effluent water quality. The one exception was a short period in FY 87 when 30-in., 22-in., and 16-in. dredges were simultaneously pumping into the south subcontainment. The combined flow rate during this period was estimated to be 160 cfs, which exceeded the critical design flow rate of 130 cfs as described in the CIMP. Also, the ponded depth could not be increased because of dike settlement following dike upgrading. The effluent water quality was degraded, and the

layer of deposited dredged material was built up very quickly and at high water content. As a result, flow was diverted to the center subcontainment.

Prevention of ponding for drying cycles

13. Weirs are opened in the subcontainments during drying cycles, and water has been allowed to drain, generally preventing ponding. However, during the period immediately following construction of the new weirs, some difficulty was experienced in decanting the ponded water from the areas immediately in front of the weirs because of the presence of mud waves formed during the weir construction. This problem has lessened as the fill elevation has increased.

Dewatering operations

14. The approach to dredged material dewatering as recommended in the CIMP is the construction of surface trenches to quickly drain precipitation from the site, thereby allowing natural drying to occur more efficiently. Periphery trenches are constructed with draglines parallel and adjacent to the dikes for drainage and to dry material for use in dike raising. A riverine utility craft (RUC) was obtained in September 1984 for use in monitoring operations and interior trenching of material at high water content. A rubber-tired rotary trencher was purchased in December 1984 for routine interior trenching operations. Photographs of the equipment and typical trenching operations during the period 1984 to 1987 are shown as Figures 3a-3e. The trenching equipment used, duration of work, and finished trenched areas are indicated in Table 1. The appearance of the trenched areas throughout the filling history is shown in aerial photographs available from the Norfolk District.*

15. The use of the RUC for trenching at early stages of dewatering sometimes has resulted in shallow trenches with soft bottoms. Such soft areas have presented problems with mobility of the rotary trencher when it must cross the RUC trenches to construct deeper trenches during later stages of dewatering. When the rotary trencher has become immobilized, recovery of the vehicle using cables operated from the dikes is a major undertaking due to the large size of the subcontainments. Also, the trencher has experienced frequent breakdowns. These problems have resulted in incomplete trenching systems within the subcontainments.

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* Due to the size of prints necessary to maintain good resolution and the cost of reproduction, these photographs are not included in this report.

PART III: FIELD MONITORING AND LABORATORY TESTING

Monitoring Plan

16. In 1982, a Monitoring Plan for the Craney Island site was developed to provide information on site operations, rates of filling, and behavior of the deposited dredged material.* The Monitoring Plan is also intended to provide data for use in updating projections of the remaining capacity of the site and for recommending changes in the management approaches. The Monitoring Plan as developed focused on physical effluent quality (efficient retention of solids) and long-term storage capacity (fill rates). Monitoring related to retention of contaminants was discussed in a report on environmental considerations of operation and management of the site.**

17. A summary of the sampling and testing recommended in the Monitoring Plan is presented in Table 2. Some of these monitoring activities have been conducted since implementation of the CIMP, and some are planned for future efforts. This part of the report summarizes the results of sampling and testing efforts conducted between 1980 and 1987, and as appropriate, compares the data with those from previous studies. Detailed data from the monitoring program are available in Norfolk District files and in contractor reports (Law Engineering Testing Company 1986).

Sediment Sampling and Characterization

18. Periodic sediment sampling throughout the project dredging areas is necessary to determine any changes in maintenance sediment properties and to provide samples for settling and consolidation tests. However, sediment sampling between 1980 and 1987 has been limited to one composite of maintenance sediment taken in 1983 (Palermo 1983, 1988) and samples of new work material taken for comparison with previous CIMP data for maintenance material (Hayes 1987).

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* M. R. Palermo. 1982. "Monitoring Program for Craney Island Disposal Area," prepared by the WES for US Army Engineer District, Norfolk, Norfolk, VA.

** M. R. Palermo, J. M. Morgan, and C. R. Lee. 1982. "Environmental Considerations in Operation and Management of Craney Island Disposal Area," prepared by the WES for US Army Engineer District, Norfolk, Norfolk, VA.

19. Plasticity data for the maintenance and new work materials are compared in Figure 4. The average properties of the materials are summarized in Table 3. These data indicate that new work material is generally of lower plasticity than maintenance material and would therefore undergo less densification due to consolidation and desiccation. Also, the new work material has an in-channel water content that is approximately half that of the maintenance material. This means that a cubic yard of new work material will initially occupy a proportionally larger volume in the disposal site than a cubic yard of maintenance material.

Effluent Quality Monitoring

20. Samples of the effluent taken during filling can be used to monitor the quality of the effluent and to verify that any applicable criteria are met. No standards or criteria have been imposed on the effluent at the Craney Island site, and no routine sampling of the effluent return water has been conducted. However, visual inspection is conducted daily during active filling operations. The effluent from the Craney Island site historically has been of acceptable quality due to the long retention times available in the pond. The subdivision of the site has reduced the potential retention time available as compared with the total area, but retention times are still high.

21. Although no recent routine sampling of effluent has been conducted, previous studies have characterized the effluent for specific time periods. A water quality monitoring program with monthly and weekly sampling (physical and chemical) was conducted at the Craney Island site from December 1973 to March 1976 (Adams and Young 1975, Adams and Park 1976). Samples of the influent and effluent were taken and analyzed for suspended solids, metals, and nutrients. In February 1983, a short-term monitoring study with hourly sampling of effluent (physical and chemical) was conducted at the Craney Island site (Palermo 1983, 1988). Samples of inflow and effluent were taken and analyzed for suspended solids, pH, dissolved oxygen, metals, nutrients, and selected polycyclic aromatic hydrocarbons (PAHs). Sediment samples were also taken for this study to conduct modified elutriate tests and settling tests for comparison of predicted effluent quality with field results.

Settlement Plates

22. Twenty-four settlement plates consisting of base plates, risers, and top plates were installed at the locations shown in Figure 5. The plates were installed to aid in determining the initial thickness of new dredged material layers, and to aid in distinguishing the settlement of underlying layers from new layers. Initial readings of the base plate elevations were taken in September 1984. Subsequent readings of the base plate elevations were taken in September 1986 and September 1987. Plots of base plate elevations are shown in Figure 6. In some instances, dredged material had accumulated to a thickness that buried the plates, and readings could not be obtained. The plates were reinstalled at these locations. It should be noted that these are not plots of the surface elevation, but of the change in elevation of the surface of the layers underlying the base plates.

23. These data generally indicate elevation changes on the order of 1 ft or less within a 3-year period. In some cases the data indicate a slight net rise in elevation, which is due to survey error or, possibly, to a mud wave effect as material is added to an adjacent subcontainment. In general, the settlement plate data indicate that little additional consolidation is occurring in deposited layers after the first few years.

Piezometers

24. Piezometers are required to monitor differences in ground water table elevations within the dredged material layers. These data aid in interpretation of dewatering behavior. Piezometers have been installed at six of the north cell settlement plate locations in clusters of two at depths of 10 and 30 ft and at five of the center cell settlement plate locations in clusters of three at approximate depths of 10, 15, and 24 ft. Readings were taken following installation, and the data are summarized in Table 4. In general, the piezometers installed in the north cell at the 10-ft depth indicate a water table within 2 ft of the dredged material surface. Piezometers installed at the 30-ft depth in the north cell indicate a water table at a depth of approximately 15 ft. The two distinct water tables indicate a perched condition for the upper dredged material layers in the north cell. Piezometers installed at all depths in the center cell generally indicate a water table within 2 ft of the dredged material surface. Several of these

readings were above the dredged material surface, indicating excess pore pressure in the dredged material layers due to placement of additional material. Additional interpretation of the ground water conditions will be possible once several readings are taken. Piezometers are also planned for installation at the remaining settlement plate locations.

Aerial Surveys

25. Aerial surveys are used to determine overall changes in the surface elevations of the subcontainments. The surveys have been flown on a yearly basis since 1985, and are flown in the fall to coincide with the end of the dewatering season and the time of alternating flow to another subcontainment. The surveys are accurate to approximately 0.1 ft. Surveys were also flown at several times during the filling period between 1964 (when the fill first exceeded the mean low water elevation) and 1980. A bathymetric survey was conducted in 1956 which establishes the condition prior to the initiation of filling. Topographic maps produced from all surveys to 1987 are available from the Norfolk District.* The settlement plate elevations determined at the time of their installation in 1984 provide another set of elevation data just prior to subdivision of the site. Table 5 summarizes the average elevations of the site and respective subcontainments as determined from the surveys.

Disposal Area Sampling and Testing

Crust sampling

26. Samples of the surface crust are necessary to determine the limiting water content of dried material and resulting volume change due to desiccation that can be expected after the drying cycle. Crust samples were taken during July 1987 at 14 of the settlement plate locations shown in Figure 5. No dredged material had been placed in the site in the previous 12 months, so the material in all subcontainments could be presumed to have formed a representative dewatered crust. The crust samples were taken by removing a crust block and sectioning the block for sampling. Samples of the dried crust and underlying wet material were taken at depth intervals ranging

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* Due to their size and the cost of reproduction, the maps are not included in this report.

from 1 to 24 in. These samples were analyzed for water content, Atterberg limits, specific gravity, percent sand, and Unified Soil Classification System (USCS) classification. Measurements of the thickness of the dried crust block, width of the block, and width of the desiccation cracks were also made. Results are given in Table 6.

27. All samples were classified as clay (CH), except three that were classified as clayey sand (SC). Both thickness and width of the crust blocks generally ranged from 8 to 12 in., with desiccation cracks 1 to 3 in. wide separating the blocks. The water content increased with depth. The wet underlying material was generally at a water content slightly above the liquid limit. The water content of the dried crust was generally between the liquid limit and the plastic limit, except for a few surficial samples that were dried to a condition below the plastic limit. Discounting samples classified as SC and those clearly taken below the dried crust, the average crust water content was 66.4 percent, equivalent to 2.0 times the average crust plastic limit. This value is a higher moisture content than the limiting value of 1.2 times the plastic limit for crust described in previous studies under the Dredged Material Research Program (Haliburton 1978). The depth of crust development as indicated by crust water contents is less than that indicated by visual observation at some locations (in excess of 2 ft).

Borings

28. Borings in the dredged fill allow characterization of the state of consolidation of materials that have been in place in the site for long periods. In conjunction with the installation of piezometers, borings were taken to a depth of 25 ft into the dredged fill in September 1985 in the center subcontainment. Borings were also taken in the north subcontainment to a depth of 30 ft into the dredged fill in October 1987. Samples from the borings were used to determine USCS classification, Atterberg limits, liquid and plastic limits, water contents, vane shear, and degree of consolidation. The moisture content and limit data are shown in Figure 7. These results are consistent with borings taken for the CIMP, showing the moisture content with depth at values in excess of the liquid limit. This indicates that little desiccation has occurred in material placed prior to 1984.

Settling and Consolidation Tests

Settling tests

29. Settling tests are used to estimate the retention of suspended solids in the site during filling and the volume initially occupied by dredged material at the end of filling. A limited number of settling tests have been conducted on maintenance and new work materials since 1980. However, the available data are insufficient to determine if settling properties are remaining constant. One settling test was conducted on new work material (Hayes 1987), which indicated that the new work material will be initially deposited at higher concentrations than maintenance materials. An additional settling test was conducted (Palermo 1988) using improved settling test procedures contained in Engineer Manual (EM) 1110-2-5027 (Headquarters, US Army Corps of Engineers 1987). The results of these tests are shown in Figures 8 and 9.

Consolidation tests

30. Consolidation tests are used to define the relationships of void ratio versus loading and void ratio versus permeability for a given material. These relationships are used in estimating the rate of change in surface elevation due to consolidation. Standard odometer tests define the material relationships for ranges of void ratio normally associated with in situ soils. Large strain consolidation tests are necessary to define the material properties at higher ranges of void ratio. A series of odometer tests was conducted for the CIMP, and additional odometer data have been collected. In 1984, a large strain consolidation test was conducted using a composite sample of dredged material taken from the site (Cargill 1985). These data were used to develop the relationship of void ratio versus effective stress shown in Figure 10 (Primary Consolidation and Desiccation of Dredged Fill (PCDDF), Cargill 1985) and are presently the best available data for the maintenance material placed in Craney Island. Odometer test results for the 1985 and 1987 borings are also presented in Figure 10 for comparison.

PART IV: DATA ANALYSIS AND INTERPRETATION

Effluent Water Quality

31. The weekly and monthly samples collected from December 1973 to March 1976 (Adams and Young 1975, Adams and Park 1976) showed that the site effectively retains suspended solids and associated contaminants. More intensive hourly sampling during 2 days in February 1983 (Palermo 1983, 1988) have shown similar results. Although the monitoring in 1983 was conducted prior to closure of the cross dikes, the ponded area during the monitoring was equivalent to the area available for ponding with the present subdivision. The data from this monitoring study showed that the site was 99.89 percent efficient in retaining suspended solids. The retention for total metals averaged 97.54 percent, reflecting a close association with suspended particles. The PAHs were found to be below detection. The results of this short-term study show that acceptable water quality of effluent can be maintained with the present method of site operation.

32. The techniques for evaluation of settling behavior and disposal area effluent quality have been improved since the CIMP was developed in 1981. Data from the settling tests conducted since 1980 (Figures 8 and 9) were analyzed using techniques now given in EM 1110-2-5027 (Headquarters, US Army Corps of Engineers 1987). The analysis was used to determine revised estimates of dredged material lift thickness and the expected effluent suspended solids as a function of flow rate.

33. Revised estimates of lift thickness were calculated for both maintenance and new work sediments. A dredging fill time of 9 months and an annual dredging volume of 5 million cubic yards were assumed. The calculations were made for each of the three subcontainments using the surface areas presently available for disposal. Results are given in Tables 7 and 8 and may be used in making projections of dike upgrading requirements.

34. The estimated effluent suspended solids concentrations were calculated only for maintenance sediment, since it exhibits less efficient settling than the new work sediment (Hayes 1987). The corresponding theoretical retention times were estimated assuming the smallest subcontainment surface area, minimum recommended ponding depth of 2 ft at the weir, and a slope of the dredged fill of 1 vertical to 2,000 horizontal. The appropriate hydraulic efficiency factor and resuspension factor corresponding to the geometry of the

pond were then applied. The resulting expected effluent solids concentrations for various flow rates are given in Table 7. These data can be used in conjunction with the CIMP guide curve for ponded depths at the weirs to estimate effluent quality.

35. From the standpoint of effluent chemical concentrations, modified elutriate test procedures are available for prediction of effluent quality (Palermo 1986). However, such tests should be conducted only if there is reason to believe that effluent from a particular disposal operation has potential to exceed applicable criteria.

36. No standards or criteria on the effluent from Craney Island have been imposed by State agencies, and a Section 401 water quality certificate was not deemed to be necessary by the State. However, the effluent should meet the Federal water quality criteria after consideration of mixing. For this reason, routine monitoring should be conducted to ensure that the effluent continues to be acceptable. Monitoring recommendations for physical effluent quality (suspended solids) are described in the Monitoring Plan. Guidance for monitoring chemical effluent quality has recently been developed (Thackston and Palermo 1988).

Storage Capacity

37. The storage capacity of the site was evaluated by comparing simulations of past filling rates and projections of future filling rates with field monitoring data. The filling rates were estimated using a mathematical model that considers both consolidation and desiccation of the dredged material. The field monitoring data used were the average fill elevations based on the aerial surveys, as given in Table 4.

38. Three types of filling simulations were performed. First, a simulation of the past filling history of the site from 1956 to 1984 was compared with field monitoring data. This simulation served as a "calibration" of the model for conditions existing prior to subdivision of the site and implementation of dewatering operations. Second, simulations of filling history from 1984 (the time of cross dike closure) to 1987 were conducted for each of the three subcontainments. These simulations served to calibrate the model for conditions of site management as has been implemented since cross dike closure. Third, simulations of projected filling rates from 1987 to the time at which the fill elevation reaches a limit of el +30 ft (Craney Island

datum) were made for each of the three subcontainments. The projected filling rates were estimated for conditions of continued site management for dewatering and for no additional management. These simulations yield an estimate of the remaining useful life of the site for various management options.

Mathematical model

39. The mathematical model used for the storage capacity evaluations in this study was the Primary Consolidation and Desiccation of Dredged Fill model, initially developed by Cargill (1985) and subsequently modified for personal computer application for the Automated Dredging and Disposal Alternatives Management System (Schroeder 1988). The PCDDF model considers the consolidation and desiccation parameters for the dredged material, initial thicknesses of material applied as a function of time, consolidation of foundation soils, and precipitation and evaporation rates. However, the model is limited to consideration of only one set of dredged material properties; therefore, alternating layers of different materials cannot be simulated. The simulations therefore cannot separately account for the layers of new work material placed in the site, which have different material properties than the maintenance material (Hayes 1987). A similar limitation applies to foundation soils, i.e., only one set of soil properties can be considered.

Selection of model parameters

40. The consolidation parameters used in the model runs were those shown in Figure 10. These are the same as used for ongoing evaluations of expansion alternatives for the Craney Island site. The desiccation parameters used in the model include a pan evaporation efficiency, a maximum crust thickness, and a drainage efficiency. These parameters were varied for several model runs in order to calibrate the filling simulations with field data. The desiccation parameters that yielded the closest calibration with field data for the conditions of management and no management are shown in Table 9. The consolidation parameters for foundation soils underlying the dredged material are also shown in Table 9.

41. Thicknesses of dredged material for each disposal operation were determined from the dredging volumes and surface areas available for placement in the disposal area. For the simulation runs for past filling through 1987, the volumes and times of placement as listed in the disposal history (Appendix A) were used. For projections of future filling rates, an annual maintenance requirement of 5 million cubic yards was assumed. The surface areas used for the entire site prior to subdivision and for each subcontainment are

shown in Table 9. The PCDDF model initiates consolidation calculations for an initial material thickness corresponding to a void ratio at zero effective stress. In calculating the initial lift thicknesses from dredged volumes, values for in-channel void ratio and zero effective stress void ratio representative of the maintenance material as shown in Table 9 were used. The precipitation and evaporation rates that were used for the simulations are shown in Table 10.

Filling simulations, 1956-1984

42. Simulations for the filling history from 1956 to 1984 are shown in Figure 11. The run that considers "consolidation only" closely matched the field data. Several similar runs were made with various levels of desiccation efficiency. The plot for minimal desiccation shown in Figure 11 most closely matched the field data while still considering reasonable desiccation efficiency for a no-management operation. The parameters used for the minimal desiccation or no-management run are shown in Table 9. The consideration of a minimal desiccation effect does not change the long-term surface elevations significantly. This is consistent with previous evaluations of the filling history of the Craney Island site using the PCDDF model (Cargill 1985).

Filling simulations, 1984-1987

43. The simulations for the filling history from 1984 to 1987 for the north, center, and south subcontainments are shown in Figures 12a, 13a, and 14a, respectively. The starting elevations for these simulations were assumed equal to the average elevation of the respective subcontainment as determined from the settlement plate installations in September 1984. All dredged material placed prior to 1984 was treated as the foundation soil for these simulations. Several such sets of runs were made with various levels of desiccation efficiency. The simulations shown were made using the parameters for desiccation with management for dewatering shown in Table 9. This set of parameters most closely matched the field data for all three subcontainments, and are the same parameters used for the simulations with management for the ongoing evaluations for expansion alternatives for the site. These results showed good agreement with the field data, especially considering the differences in volumes and sequencing of disposal for the three subcontainments.

Filling projections, 1987 to el +30 ft

44. The simulations for the filling history from 1984 to 1987 and for filling projections from 1987 to el +30 ft mlw for the north, center, and south subcontainments are shown in Figures 12b, 13b, and 14b, respectively.

The same desiccation parameters as shown in Table 9 for management for active dewatering were used for these projections. The material was assumed to be placed at a rate of 5 million cubic yards per year, alternating between subcontainments, beginning in October 1987 with the north cell. Placement was assumed to rotate from the north to the center to the south and back to the north subcontainment. For purposes of these projections, a subcontainment was considered to be filled if the consolidation and desiccation following the fill cycle did not result in a surface elevation below el +30 ft.

45. These projections indicate that the north cell would barely accommodate the fill cycle during FY 94 but would recover capacity for a partial fill cycle during FY 97. The center cell would easily accommodate the fill cycle for FY 95 and would barely accommodate the fill cycle during FY 98. The south subcontainment would barely accommodate the fill cycle for FY 96 and would recover capacity for a partial fill cycle during FY 99. All three subcontainments would recover capacity during the dewatering cycle following these latter filling cycles in a similar manner. This would leave a remaining capacity in all three cells at the end of FY 99 that could be used for the final fill to el +30 ft. Considering the partial recovery of cells, the divided site should have sufficient capacity to accommodate the dredging requirements through FY 2000.

46. For comparison, Figure 15a shows a simulation of filling from October 1984 to an elevation of +30 ft, assuming that the site had never been subdivided. The desiccation parameters for no management shown in Table 9 were used. The filling history from 1984 to 1987 was used with an assumed fill rate of 5 million cubic yards thereafter. The material was assumed to be spread out over the entire site. The starting elevation for this simulation was assumed equal to the average elevation determined for the settlement plate installation in September 1984. This simulation shows that an undivided site with no management would be filled during FY 97.

47. Figure 15b shows a simulation of filling from October 1987 to an elevation of +30 ft, assuming that alternation between subcontainments and dewatering was abandoned in October 1987. The desiccation parameters for no management shown in Table 9 were used, and the material was assumed to be spread over the entire site. The starting elevation for this simulation was assumed equal to the average surface elevation for all subcontainments from the October 1987 survey. This simulation shows that, if management were abandoned in October 1987, the site would be filled during FY 98.

48. Based on these comparisons, subdivision of the site and dewatering operations conducted from October 1984 to October 1987 have resulted in a gain in useful life of approximately 1 year. Management from October 1984 through October 2000 would increase the life of the site by approximately 3 years. Considering October 1984 as a starting point, a gain of 3 years over a useful life of 12 years with no management (FY 85-97) represents a 25-percent gain in capacity. This is a significant benefit, but not as great as had been anticipated in the CIMP. The differences in the anticipated fill rate as described in the CIMP and the actual fill rate under the management program to date are discussed in Appendix B.

PART V: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Site operations

49. Based on the monitoring data collected to date, the following conclusions regarding site operations and management are made:

- a. The construction requirements of the CIMP have been successfully completed to include closure of cross dikes, construction of new weirs, and upgrading of the dike systems as needed.
- b. The sources and nature of dredged material placed at the site have generally remained unchanged, but data on the sediments are limited.
- c. In general, the site has been operated by alternating inflows between the subcontainments in accordance with the CIMP. However, the alternation of flow has not been on a strictly annual basis, and flows have been diverted to more than one subcontainment in all years since closure of the cross dikes.
- d. Few problems have been encountered in maintaining a sufficient pond in the subcontainments during filling cycles, and in preventing large ponds from developing in subcontainments during drying cycles.
- e. Trenching operations have been conducted in all three of the subcontainments using either the RUC or rotary trencher. However, there have been problems with equipment maintenance and mobility, and the trenching systems have not been completed over the total area of the subcontainments for some cycles.

Monitoring program

50. Based on the monitoring data collected to date, the following conclusions regarding the monitoring program and its interpretation are made:

- a. The Monitoring Plan, with all its components, is considered necessary to obtain the data needed for sound management decisions.
- b. Some components of the Monitoring Plan, such as periodic aerial surveys and settlement plate surveys, have been fully implemented. All other components have been implemented on a sporadic or partial basis (such as borings, piezometers, and crust sampling) or have not yet been implemented (such as periodic sediment sampling and effluent quality sampling).
- c. The limited sampling and testing of maintenance and new work sediments indicate that the nature of these materials is clearly different, and their behavior in the disposal site with respect to settling, consolidation, and desiccation is different. In general, the new work sediments initially occupy a greater volume in the site (per cubic yard dredged), settle to

a higher density, consolidate less, and desiccate less than the maintenance sediments.

d. The settlement plate data to date indicate that the settlement of layers deposited prior to 1984 is generally less than 1 ft, indicating that additional consolidation of material from a previous filling cycle due to placement of material from the next filling cycle will be limited.

e. The limited piezometer data generally indicate a water table within 2 ft of the dredged material surface. The data also indicate a perched water table condition for the upper layers in the north subcontainment and excess pore pressure in the material in the center subcontainment.

f. The aerial surveys have proven to be an efficient and reliable method of obtaining data on the overall changes of surface elevations within the subcontainments.

g. Disposal area sampling has been limited to one set of crust samples and borings taken within two subcontainments. Based on these data, the material with depth remains at water contents in excess of the liquid limit, confirming the earlier findings that little desiccation had occurred in years prior to 1984. The crust samples indicate that the desiccated crust developed to a depth of 8 in. to 1 ft within a year and to a water content of approximately 2.0 times the plastic limit. The rate of crust development indicated by the sample data is slower than anticipated in the CIMP. However, visual observations indicate that crust has developed to depths in excess of 2 ft at some locations.

h. Effluent water quality monitoring has not been conducted on a routine basis, but short-term monitoring and daily inspections indicate that the site is efficient in retention of solids and associated contaminants.

i. Mathematical model simulations of past filling history between 1956 and 1984 (prior to closure of cross dikes) and 1984 to 1987 (after closure) show good agreement with field data. These simulations also serve to calibrate the model for future projections of fill rates for both the no-management and the management alternatives.

j. Based on the monitoring data collected to date and projections of future fill rates, the site will be filled to el +30 ft during FY 2000 if the present intensity of management is continued. If the site had not been subdivided and management for dewatering not initiated, the site would fill during FY 1997. Therefore, the CIMP as implemented to date will result in a gain in useful life of approximately 3 years or 25 percent of the remaining capacity. This benefit is less than the maximum possible benefit anticipated in the CIMP. The differences are due to a combination of factors, including inaccuracies of models in projecting long-term fill rates, inefficiencies in implementing the CIMP, natural inefficiencies of desiccation processes, and the placement of significant volumes of new work material in the site.

k. The total time period for which the site has been operated with management is 3 years (FY 85-87). During this period, each of the three subcontainments has been through only one total cycle of filling and dewatering. The site history with management is therefore insufficient to conclusively determine the associated benefits.

Recommendations

Management approaches

51. Based on the results and interpretation of site operations and monitoring data to date, it is recommended that the present management approaches be continued. Any increase in the useful life of the site is of critical importance. Rotation of flow between subcontainments should be continued on an annual basis, and diversion of flow to subcontainments during their drying cycles should be avoided if at all possible.

52. Some specific recommendations related to dewatering operations are as follows:

a. Continue to construct periphery trenches with draglines working from the dikes, but limit the effort to creation of a shallow trench to form a drainage path. Material from this trench should be brought up on the dike face to dry for later use in raising the dike.

b. Consider a reduced cross section for the subdivision dikes, using only dewatered dredged material to upgrade the dikes. At present, material to raise these dikes is primarily sand, which must be trucked using 10-ton trucks. The dike section needed to support these trucks must be much larger and of better quality material than that needed to support a dragline on mats. With a reduced cross section, the access along the cross dike could be limited to all-terrain vehicles.

c. Consider a shift in the schedule for "changeover" of pumping to the next cell. This is presently done to coincide with the fiscal year. A change in spring may provide a better opportunity to gain two full drying seasons.

d. Discontinue using the RUC. This will avoid creating depressions in the crust with soft bottoms in which the rotary trencher can later become immobilized.

e. A necessary inventory of spare parts for the rotary trencher should be identified and acquired. This would eliminate many of the long delays in construction of trenches due to equipment maintenance problems.

f. Consider contracting the trenching operation as a possible solution to the lack of dedicated time for trenching by onsite Government personnel. Trenching in disposal areas in other Districts is now done by contract, and payment based on performance would encourage the contractor to provide maintenance services and perhaps a second trencher.

g. A trenching window with time after cessation of inflow and before a cutoff date beyond which no further trenching would be deemed practical should be established.

Monitoring

53. It is recommended that all components of the Monitoring Plan be implemented. This would include the following:

a. Grab samples should be taken on a yearly basis in the major shoals to define changes in sediment characteristics and to provide samples for settling and consolidation tests.

b. Borings should be taken in the center and south subcontainments in conjunction with installation of piezometers.

c. Surface sampling of crust blocks should be done yearly until the desiccation behavior is documented for varying periods of drying.

d. Effluent samples should be taken routinely for suspended solids analysis. Chemical monitoring should be considered for those disposal operations that have potential for effluent discharges in excess of water quality criteria (after consideration of mixing).

e. Piezometers and settlement plants should be monitored on an intensive schedule for several drying cycles, and yearly thereafter.

f. The runoff behavior of trenched and untrenched subcontainments should be monitored for several representative storm events.

g. Aerial surveys should be continued on an annual basis.

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Table 1

Summary of Trenching Operations

Time Period	Equipment	Trenched Area
Apr-Jun 85	Rotary trencher	Entire center subcontainment
Jun-Aug 86	Rotary trencher	South half of south subcontainment
	Riverine utility craft	Entire north subcontainment
Jul-Sep 87	Rotary trencher	Entire north subcontainment

Table 2

Summary of Sampling, Testing, and Monitoring Requirements for Craney Island Disposal Area

Sample Type	Location	Number of Samples and Interval*	Laboratory Tests**	Remarks
			Sampling and Testing	
Channel grab	Navigation channel (selected locations)	15 to 20 grabs annually	WC, AL, SG, G	Grab samples to be taken immediately prior to dredging in shoal areas
Channel grab	Navigation channel	2 or 3 bulk annually	Column, consolidation	Locations selected based on general grab sample results
Undisturbed borings	Disposal area	18 borings to 30-ft depth	WC, AL, SG, consolidation	Borings within the disposal area may be taken within each of the three subcontainments following closure of interior dikes and sufficient drying of crust to support light-weight drilling equipment (FY 83-86). Piezometers should be installed in each borehole. Approximately six borings can be placed in each subcontainment per year. Borings need not be again taken until the fill has risen 10 ft or more
Surface samples	Disposal area (selected locations)	50 to 75 samples annually	WC, AL, SG	Samples taken of the dried crust
Influent	Dredge discharge	48 samples each	Suspended solids	Inflow concentration will be the average of 48 samples taken at specified time intervals during active operations. This sampling should be repeated for each dredge/dredging operation that occurs repetitively at Craney Island. This information is also useful for estimating production rates
Effluent	Each operating weir	3 samples weekly	Suspended solids	Effluent monitoring will become increasingly important once subcontainments are operational. Visual inspections of effluent should be made daily
			Other Monitoring	
Piezometers	--	--	--	Readings taken as below for settlement plates
Settlement plates	--	--	--	Readings taken weekly for 4 weeks, monthly for 6 months starting at the beginning of an inactive cycle, and a final reading taken prior to initiation of an active cycle
Topographic surveys	--	--	--	Surveys taken by aerial means on a yearly basis
Hydrologic data	--	--	--	Rainfall data and outflows monitored for several representative storm events

* If data sufficiently define trends over several sampling intervals, sampling and testing may be reduced or discontinued.
** WC = water content; AL = Atterberg limits; SG = specific gravity; G = gradation (course-grained samples only).

Table 3

Comparison of Characteristics for Maintenance and New Work Sediments

Characteristic	Maintenance Sediment	New Work Sediment
Specific gravity	2.75	2.70
Sand content, percent	15	12
Liquid limit, percent	128	83
Plasticity index, percent	88	58
In situ water content, percent	205	108

Table 4

Summary of Piezometer Data

Location	Well Depth ft	Riser Height ft	Water Depth, ft Below Top Pipe	Below G.S.*
		Center Subcontainment, 11 Dec 85		
SP-3	10	9.7	11.2	1.5
SP-10	10	10.2	Mud at 10	--
	24.3	6.9	4.9	2*
SP-9	11.3	9.75	11.2	1.45
	14.75	5.3	7.2	1.9
	15.1	5	6.4	3.3
SP-15	10	10.3	Mud at 10	--
	23.3	7.1	6	1.1*
SP-16	4.75	5.3	4.9	0.4*
	15	8	9	1
	23.3	7.1	8	0.9
	--	8	6.5	1.5*
SP-21	10	5	5.4	0.4
	15	5	4.4	0.6*
	24.5	5.5	16	10.5
		North Subcontainment, 25 Sep 87		
SP-11	10	7	7	0
	30	7.5	18	11.5
SP-12	10	7	16.5	9.5
	30	7.3	26.5	19.2
SP-14	10	7	8	1
	30	7	2.5	18
SP-23	10	7	11	4
	30	7.2	23	16
SP-24	10	6.67	8	1.33
	30	7	24	17

* Above ground surface.

Table 5

Average Surface Elevations (ft) Based on Aerial Surveys

Date	Entire Site	North Cell	Center Cell	South Cell
Oct 1953	-10.0	--	--	--
Dec 1964	-0.7	--	--	--
Aug 1965	0.4	--	--	--
Oct 1968	4.6	--	--	--
Dec 1975	13.0	--	--	--
Oct 1977	14.2	--	--	--
Mar 1980	15.4	--	--	--
Sep 1984*	18.39	19.13	16.95	19.10
Sep 1985	18.82	19.91	16.39	20.16
Oct 1986	19.90	19.95	19.71	20.03
Sep 1987	20.42	20.00	19.41	21.86

* Initial reading following settlement plate installation.

Table 6

Material Properties of Crust Samples

Settlement Plate	Thickness of Crust Block, in.	Average Width of Desiccation Crack, in.	Average Width of Crust Block in.	Sample Depth in.	Classification	Laboratory Tests* Wn, %	LL %	PL %	PI	SG	% Sand
SP 1	(1)**	(2)(3)	--	1	CH	47.5					3.9
				6		65.4	98	24	64	2.73	6.6
				12		83.4					3.4
				21		127.1					1.3
SP 2	9	(2)(3)	--	1	CH	33.1					4.1
				4		69.4	78	29	49	2.73	6.0
				8		78.7					2.1
				10		101.8					12.3
SP 3	(1)	(2)(3)	--	18	SC	49.9	30	23	7		53.8
SP 4	12	3	10	1	CH	33.5					0.2
				6		98.7	109	38	71	2.73	1.4
				11		128.1					0.8
				13		160.4					0.6
SP 9	12	2	10	1	CH	48.7					0.9
				6		101.4	116	40	76	2.74	1.1
				11		101.9					2.7
				13		163.5					0.4
SP 10	(1)	(2)(3)	--	1	SC	42.8					7.2
				4		20.2					81.8
				8		36.2					59.5
				12		26.4					85.4
SP 11	8	(2)(3)	--	1	CH	15.5					6.2
				4		111.1	106	37	69	2.74	0.3
				8		99.4					0.2
				12		111.2					2.0
SP 12	(1)	(2)(3)	--	1	CH	22.3					27.7
				6		45.7	57	24	33	2.73	26.3
				12		55.5					20.7
				16		57.3					11.6
SP 13	(1)	(2)(3)	--	1	CH	65.2					0.8
				5		51.8	75	28	47	2.72	7.6
				10		72.5					6.3
				15		74.2					10.8
SP 14	8	(2)(3)	--	1	CH	81.0					0.8
				4		106.8	76	29	47	2.79	1.3
				7		58.8					18.7
				9		74.3					10.0
SP 15	9	1	11	1	CH	13.7					0.3
				4		82.5	97	35	62		7.6
				8	SC	28.8					58.0
				10		43.9					49.1
SP 16	9	2	12	1	CH	16.2					0.1
				4		67.6	85	33	52		0.3
				8	SC	38.2					48.8
				10		36.2					66.8
SP 21	11	3	8	1	CH	47.7					0.02
				5		62.4	106	37	69	2.73	0.8
				9		95.5					0.02
				12		140.5					0.02
SP 24	(1)	(2)(3)	--	1	SC	75.9					1.5
				9		28.4					72.4
				18		27.0					79.1
				24		(Missing)					

* Wn - natural water, LL - liquid limit, PL - plastic limit, PI - plasticity index, SG = specific gravity, and % Sand - amount of material greater than No. 200 sieve size.

** Numbers in parentheses are defined as follows: (1) Crust block/dredge material interface is not evident; therefore, sampling depth is arbitrarily established; (2) No desiccation cracks; and (3) Dredged material filled in cracks.

Table 7

Expected Effluent Suspended Solids

Flow Rate cfs	Minimum Residence Time, hr	Theoretical Residence Time, hr	Column Suspended Solids mg/ℓ	Effluent Suspended Solids at Weir, mg/ℓ
20	344	176	15	30
40	172	88	15	30
60	115	59	18	36
80	86	44	22	44
100	69	35	25	50
120	57	29	28	56
130	53	27	29	58

Table 8

Estimated Dredged Material Lift Thickness

Material	Subcontainment	Lift Thickness, ft
Maintenance	North	6.7
	Center	6.1
	South	6.3
New work	North	6.8
	Center	6.2
	South	6.4

Table 9

Desiccation Parameters for Model Simulations

Parameter	No Management	Active Dewatering
Surface drainage efficiency, percent	25	100
Maximum evaporation efficiency, percent	10	100
Saturation at end of desiccation, percent	80	80
Maximum crust thickness, ft	0.5	1.0
Time to desiccation after filling, days	30	30
Elevation of fixed water table, ft msl	+1.5	+1.5
Void ratio at saturation limit	6.5	6.5
Void ratio at end of desiccation	3.2	3.2
In-channel void ratio	5.93	5.93
Void ratio at zero effective stress	10.5	10.5
Void ratio of incompressible foundation	0.65	0.65
Permeability of incompressible foundation	3.0 E-04	3.0 E-04
Area available for dredged material placement, acres		
Entire site	2,400	2,400
North subcontainment	658	658
Center subcontainment	720	720
South subcontainment	702	702

Table 10

Precipitation and Evaporation Rates, Craney Island Disposal Area

Month	Precipitation in.	Pan Evaporation in.	Excess Evaporation, in.	
			100-Percent Infiltration	75-Percent Infiltration
January	3.4	0.0	--	--
February	3.3	0.6	--	--
March	3.4	1.0	--	--
April	2.7	4.5	1.8	2.4
May	3.3	7.0	3.7	4.5
June	3.6	7.7	4.1	5.0
July	5.7	7.7	2.0	3.4
August	5.9	6.6	0.7	2.2
September	4.2	4.9	0.7	2.2
October	3.1	3.6	0.5	1.3
November	2.9	1.2	--	--
December	3.1	0.0	--	--
Total	44.6	44.8	13.5	21.0

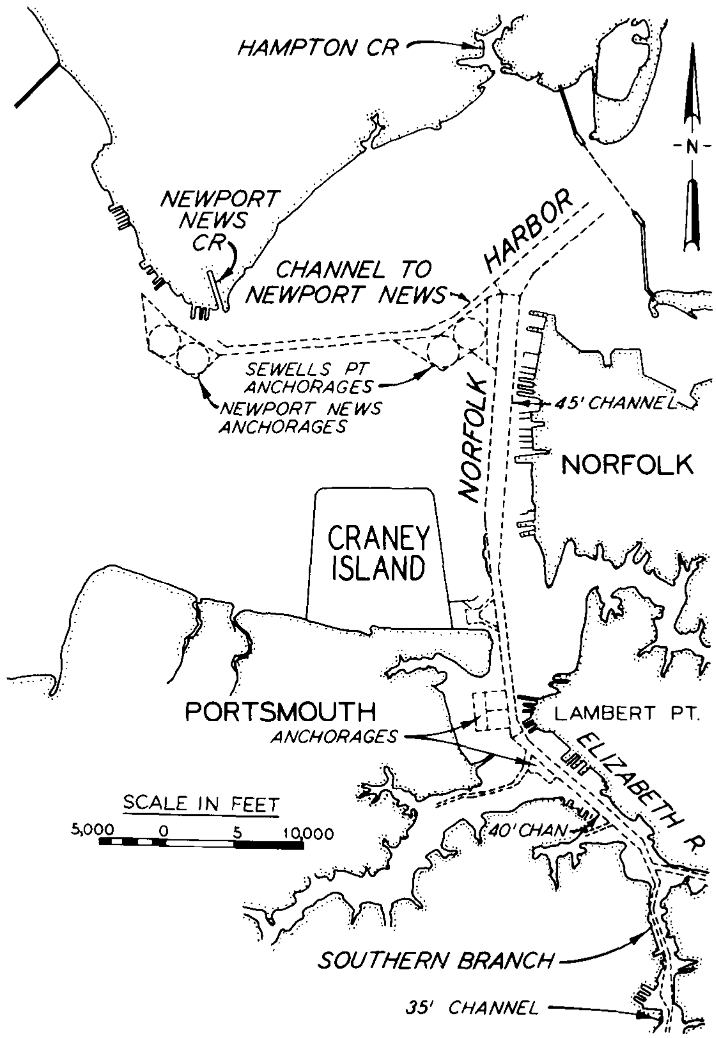


Figure 1. Vicinity map showing Norfolk Harbor and Craney Island disposal area

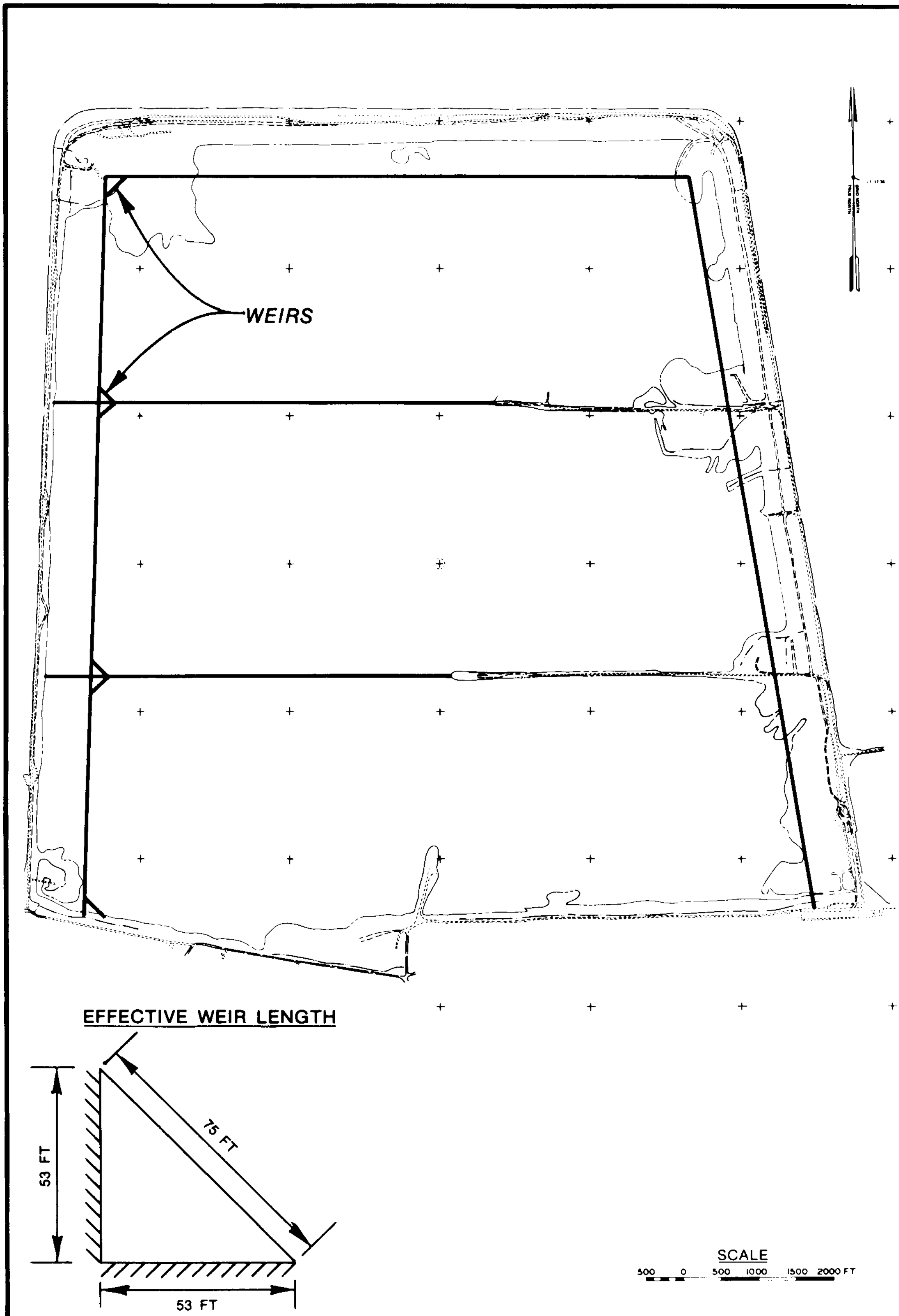
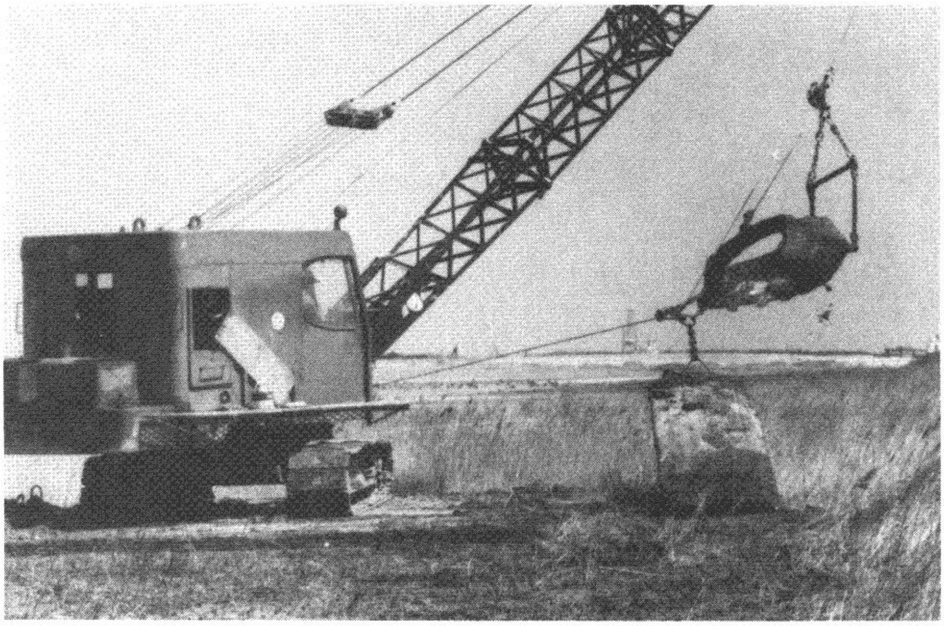
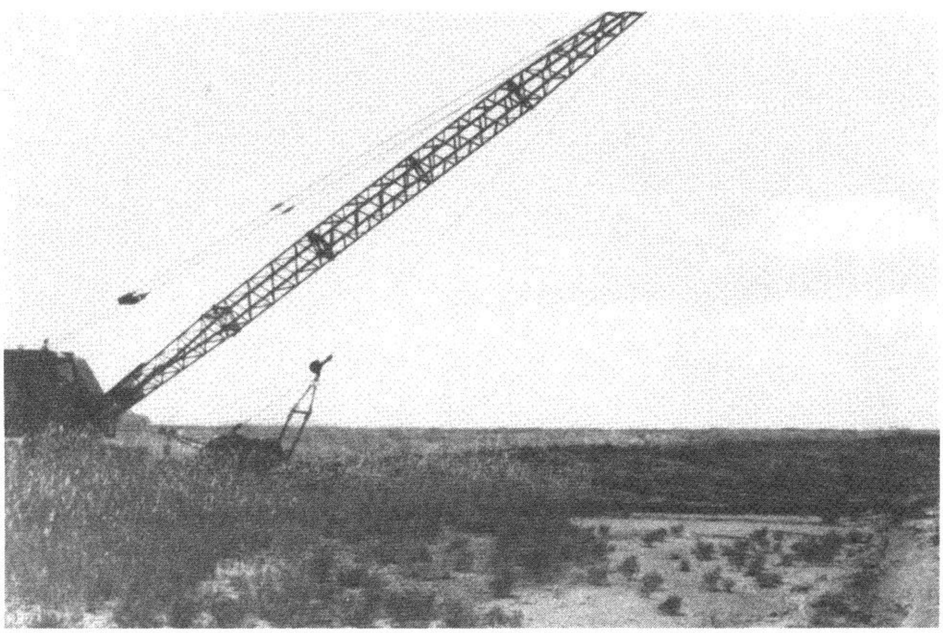


Figure 2. Configuration of Craney Island disposal area

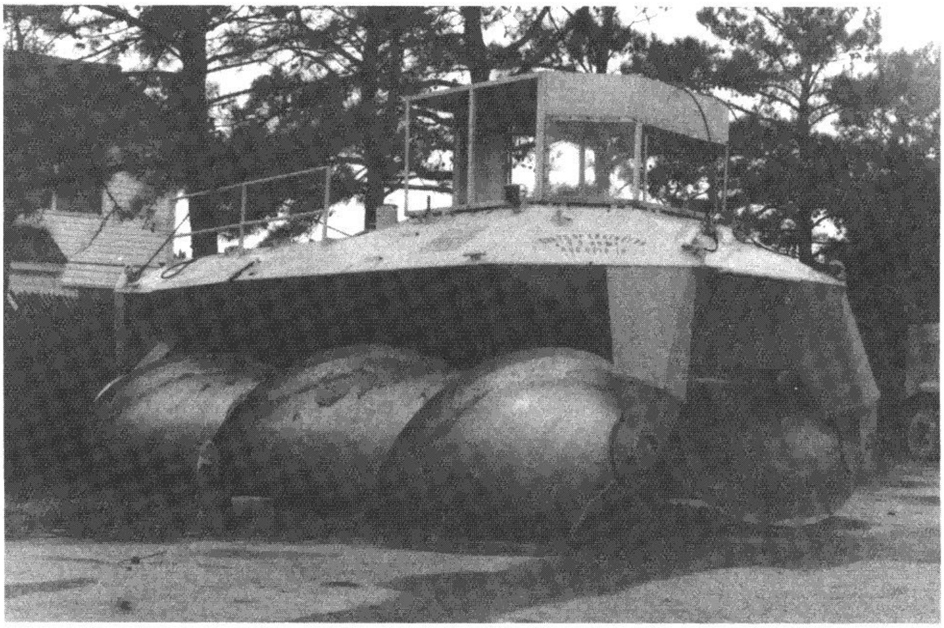


a. Dragline operating on mat

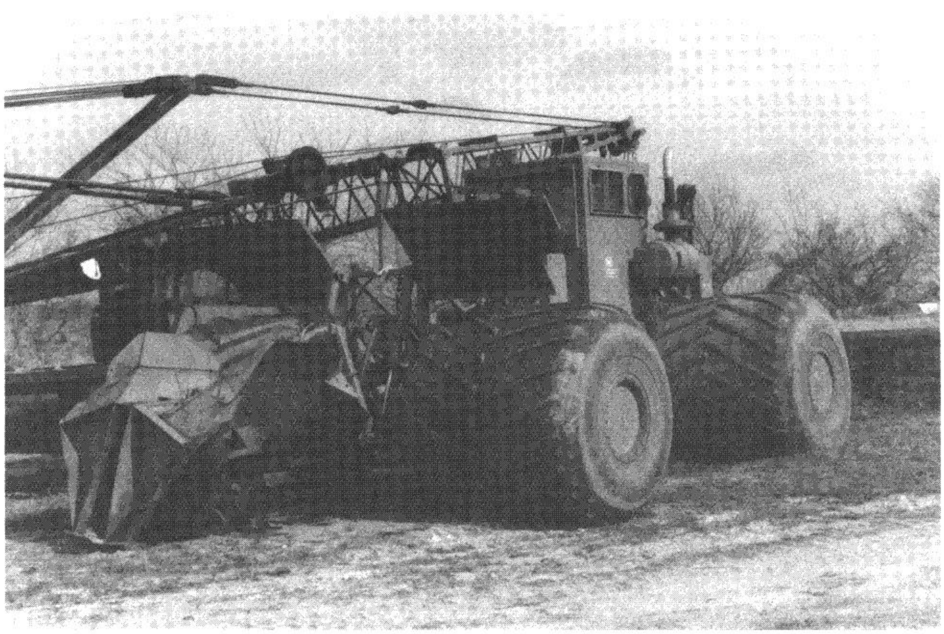


b. Dragline-constructed trenches

Figure 3. Photographs of trenching equipment and dewatering operations (Sheet 1 of 3)

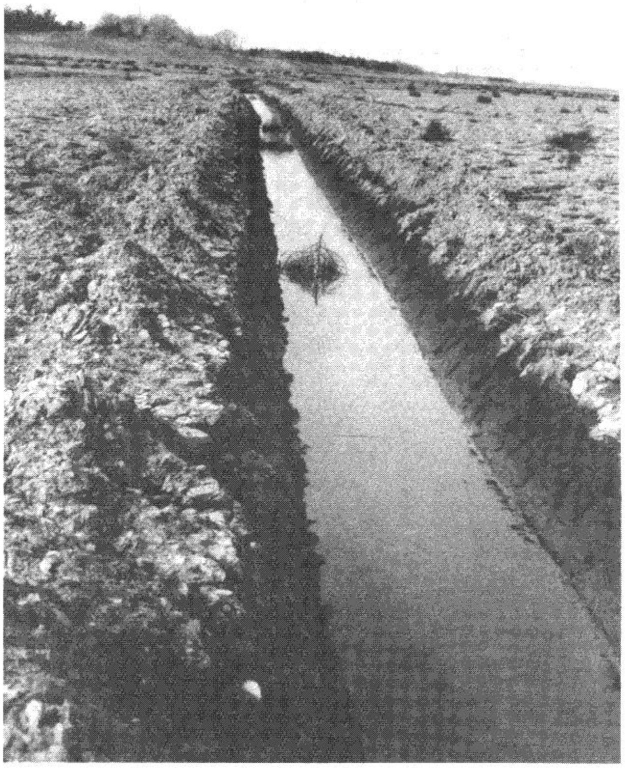


c. Riverine utility craft



d. Rubber-tired rotary trencher

Figure 3. (Sheet 2 of 3)



e. Close-up of trenches

Figure 3. (Sheet 3 of 3)

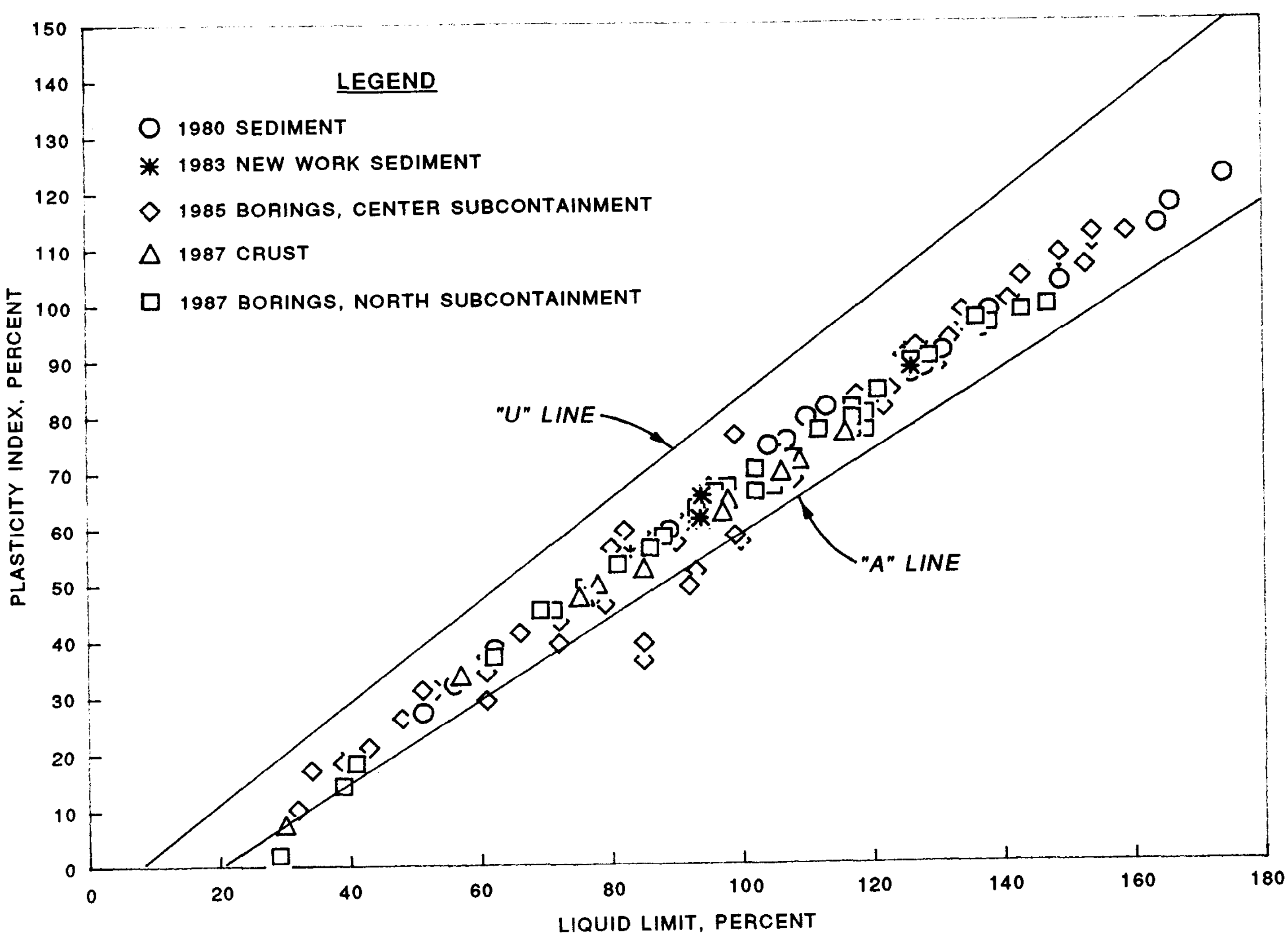


Figure 4. Plasticity data for new work and maintenance sediments

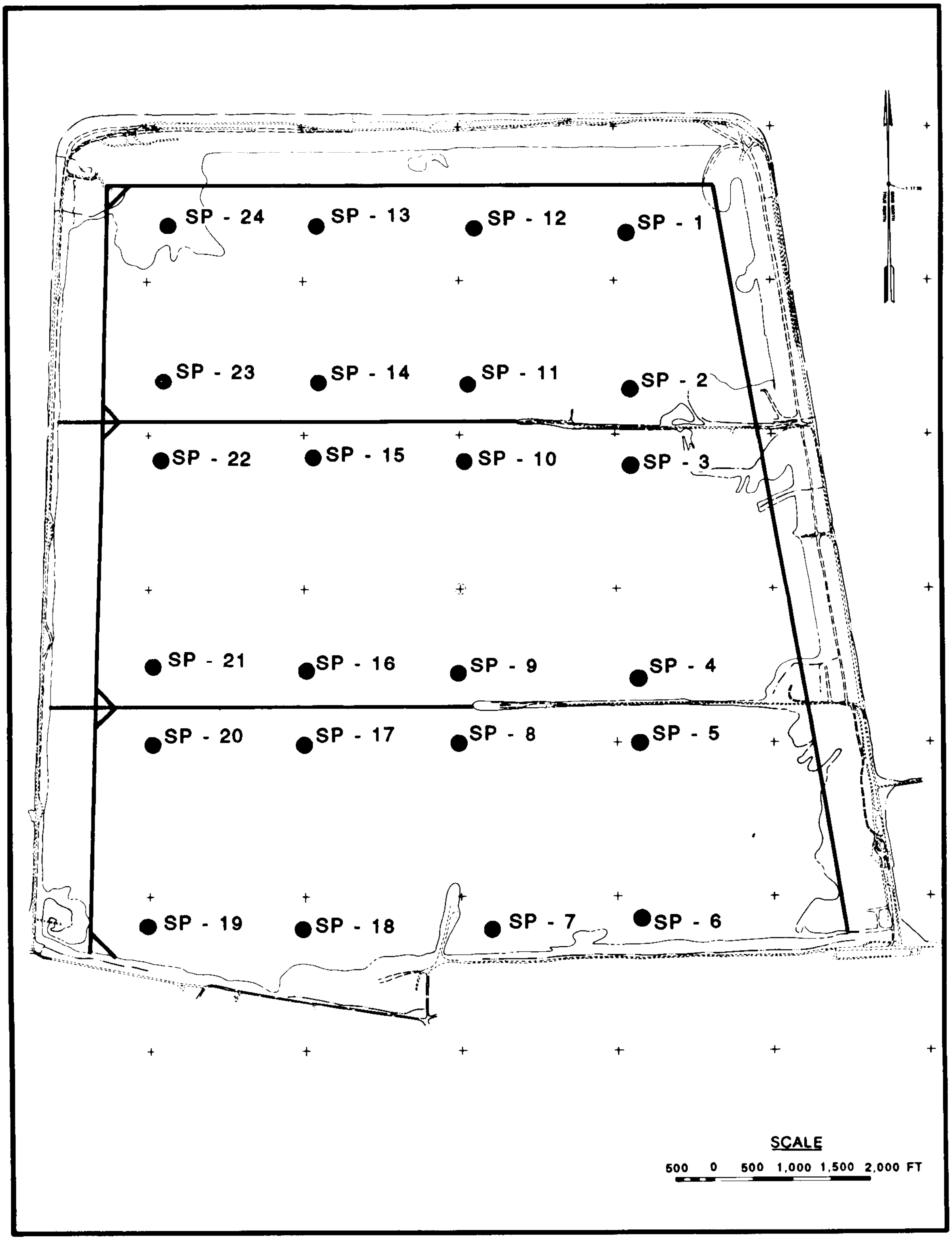
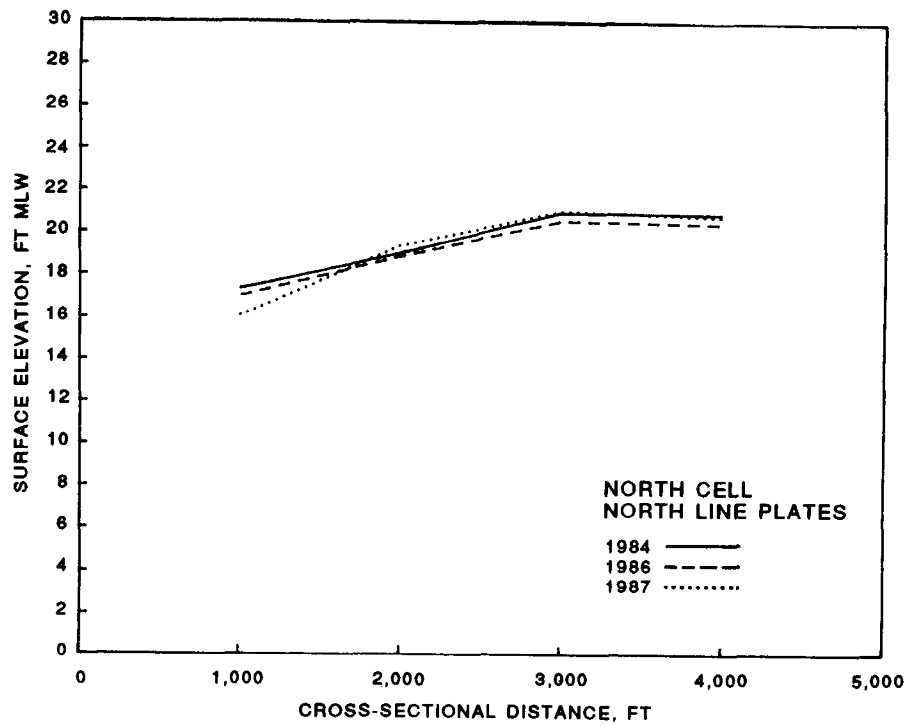


Figure 5. Locations of settlement plates



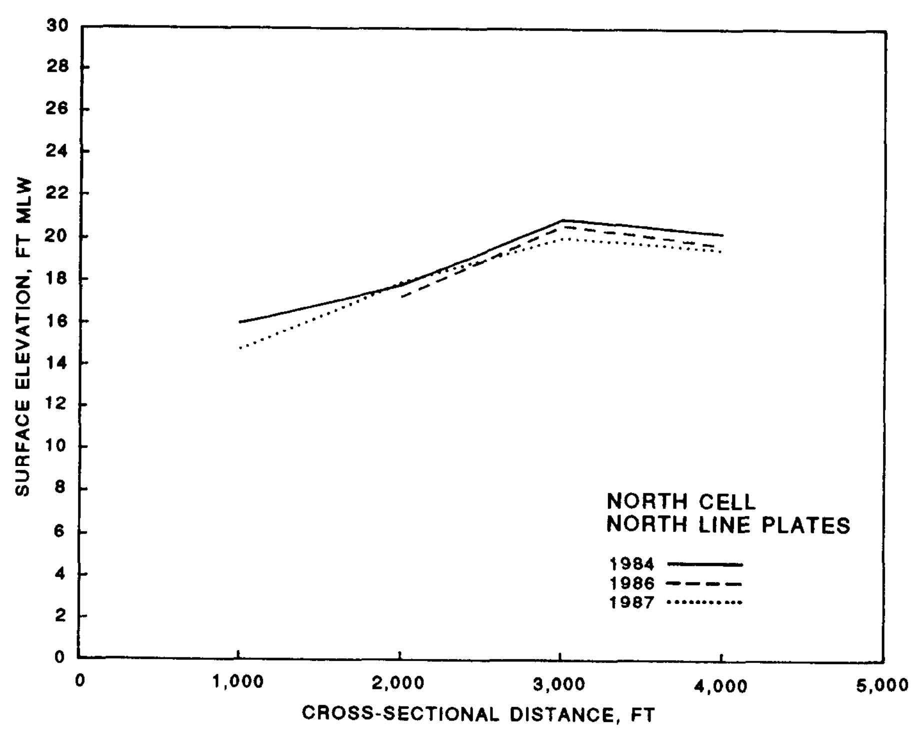
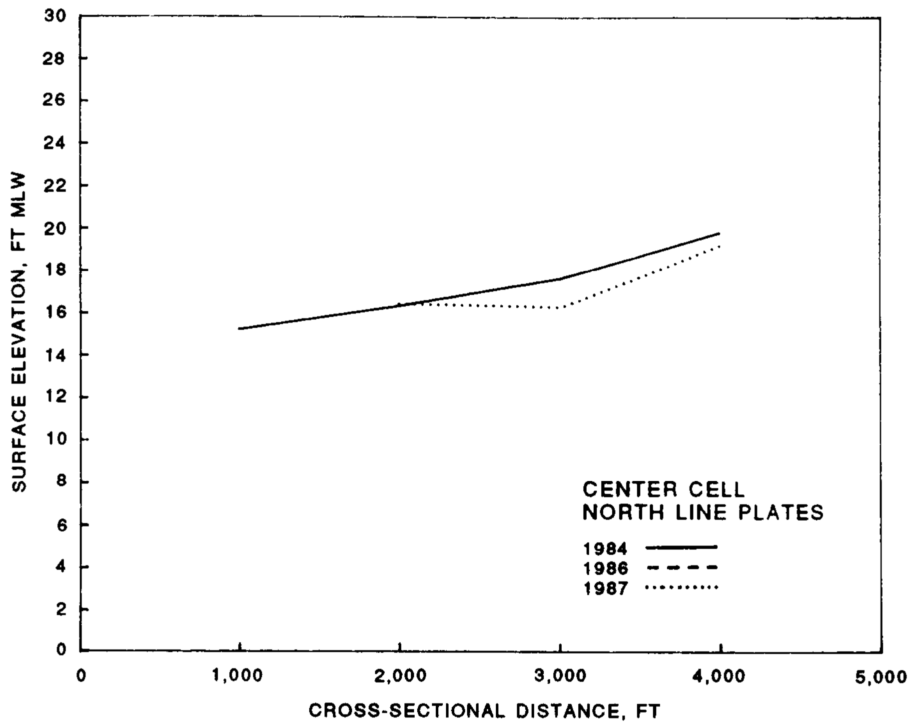


Figure 6. Settlement plate elevations (Sheet 1 of 3)



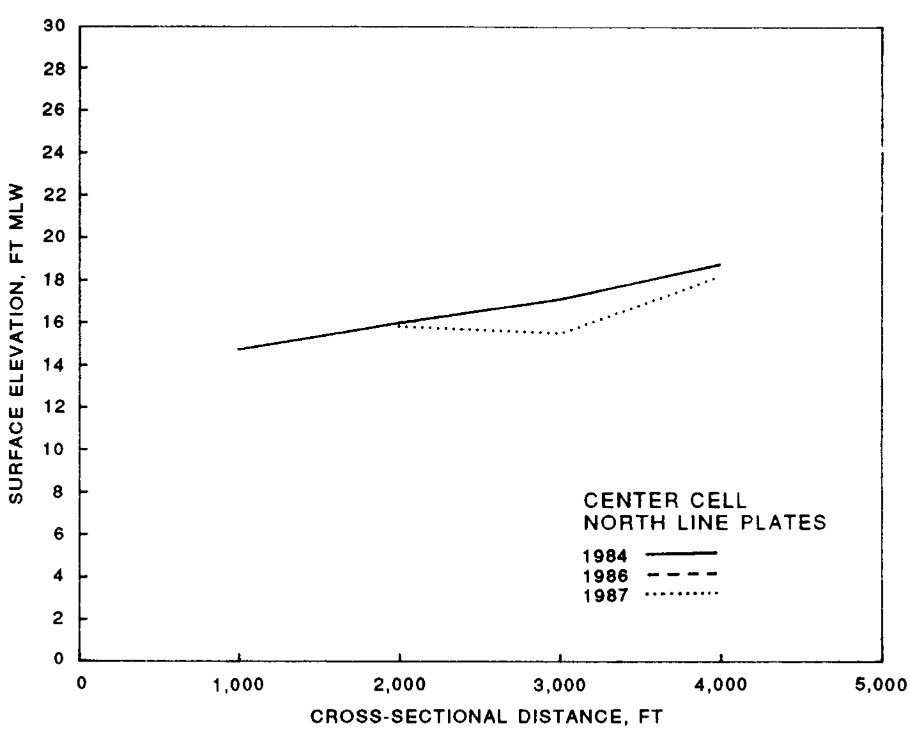
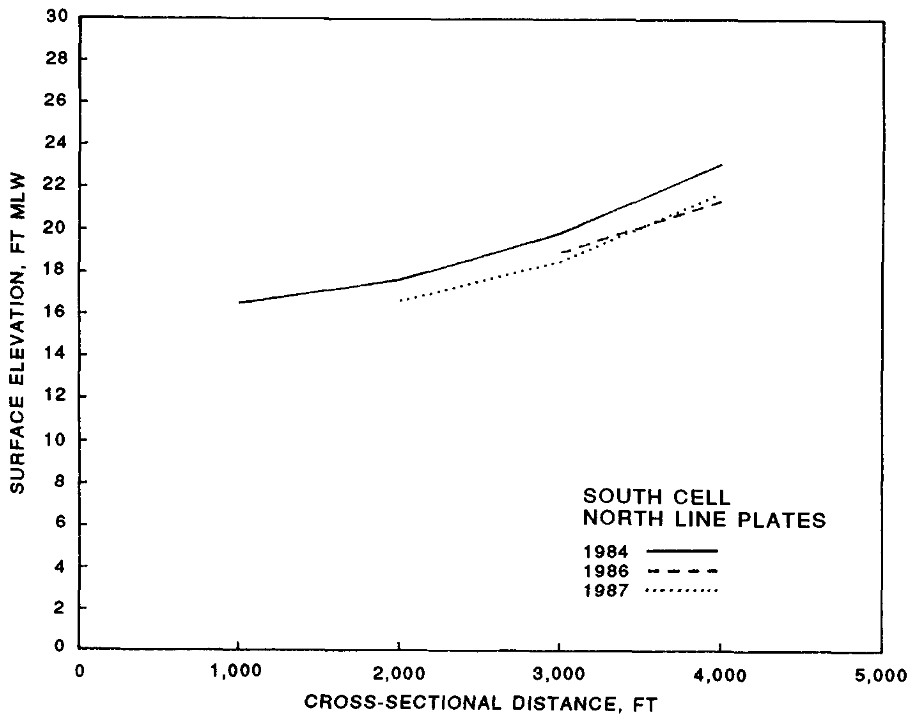


Figure 6. (Sheet 2 of 3)



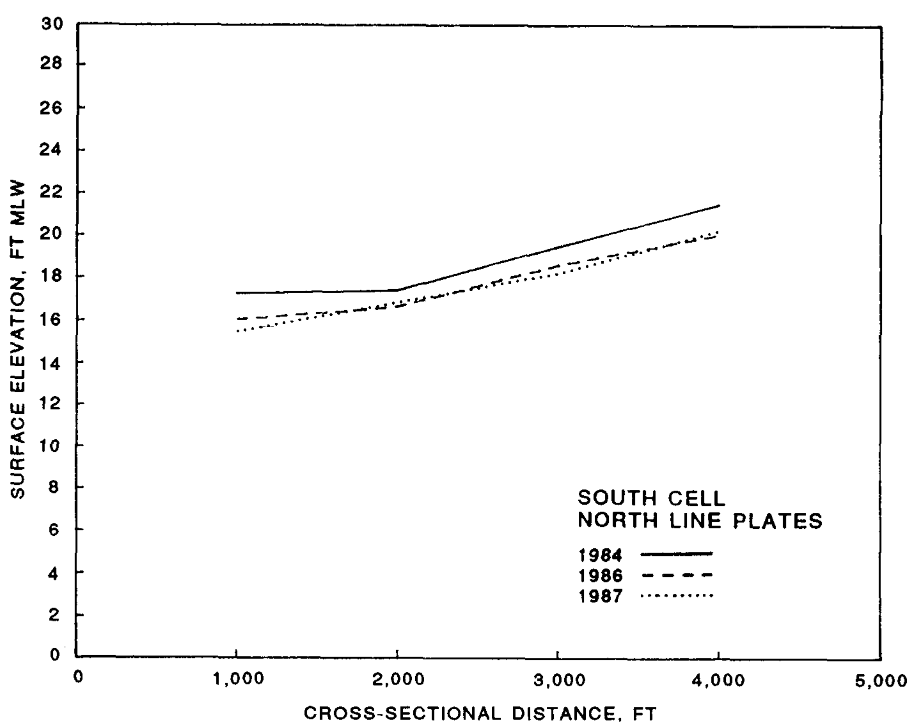


Figure 6. (Sheet 3 of 3)

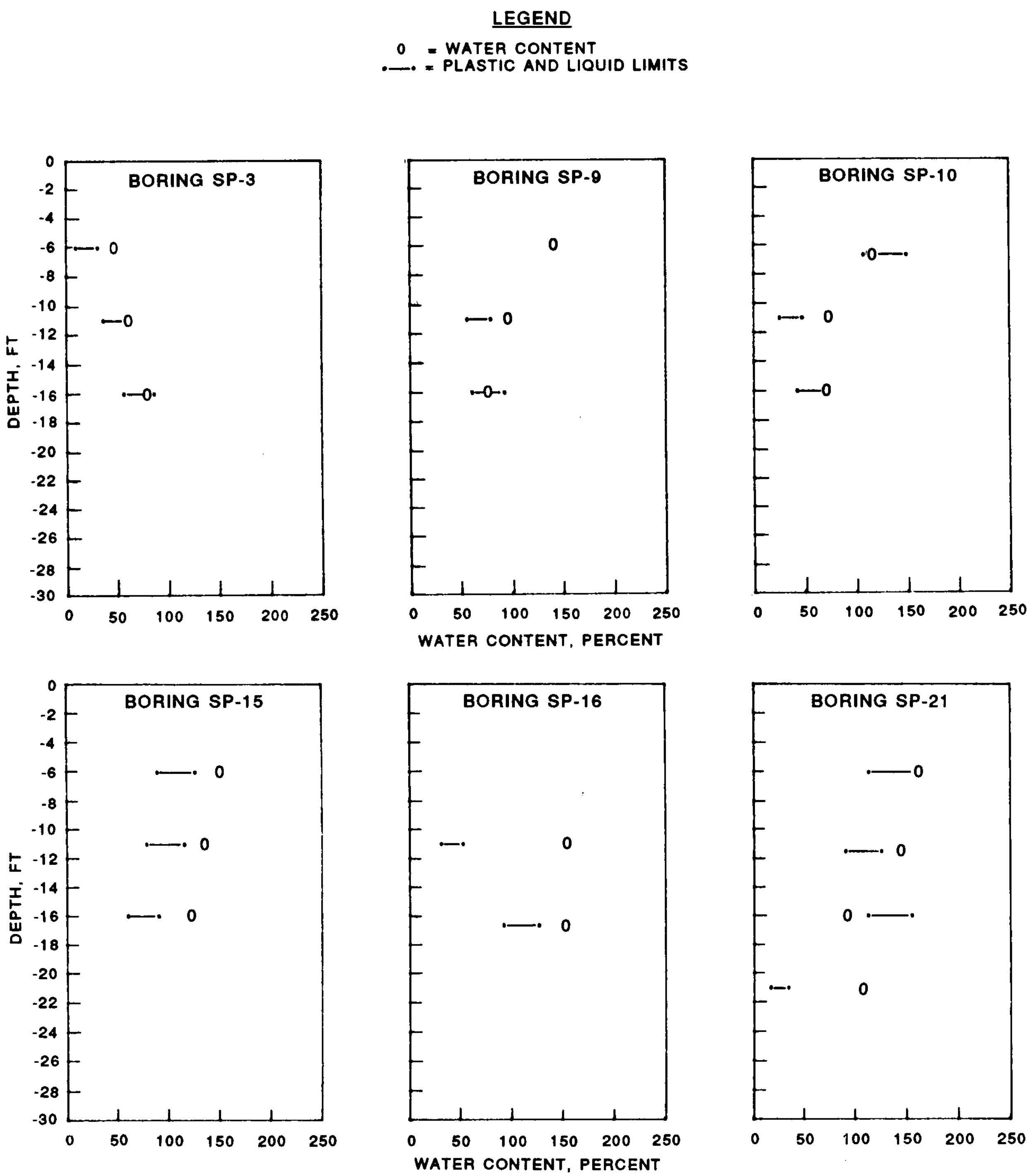


Figure 7. Plasticity and water content values for boring samples

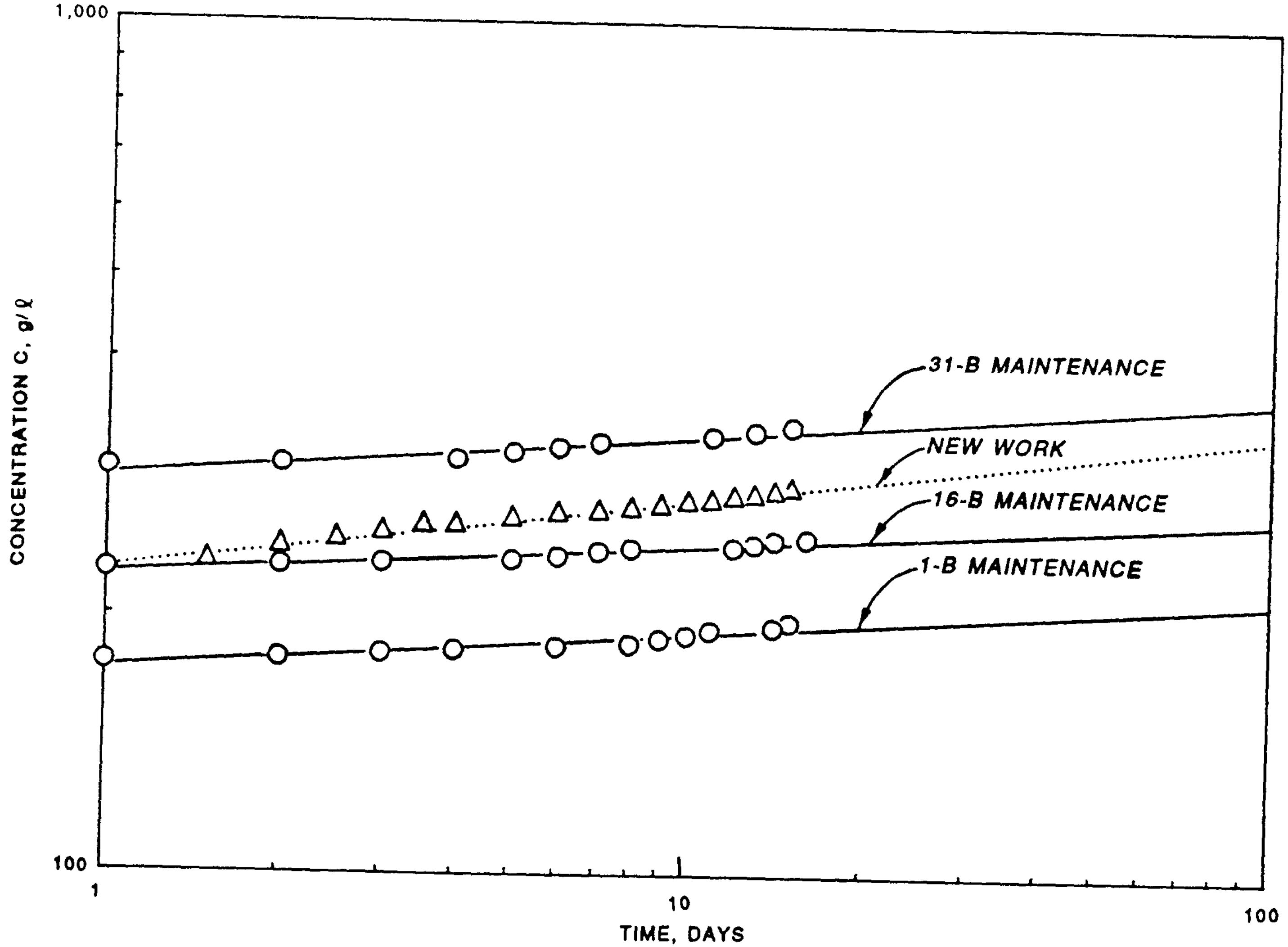


Figure 8. Concentration versus time for compression settling tests

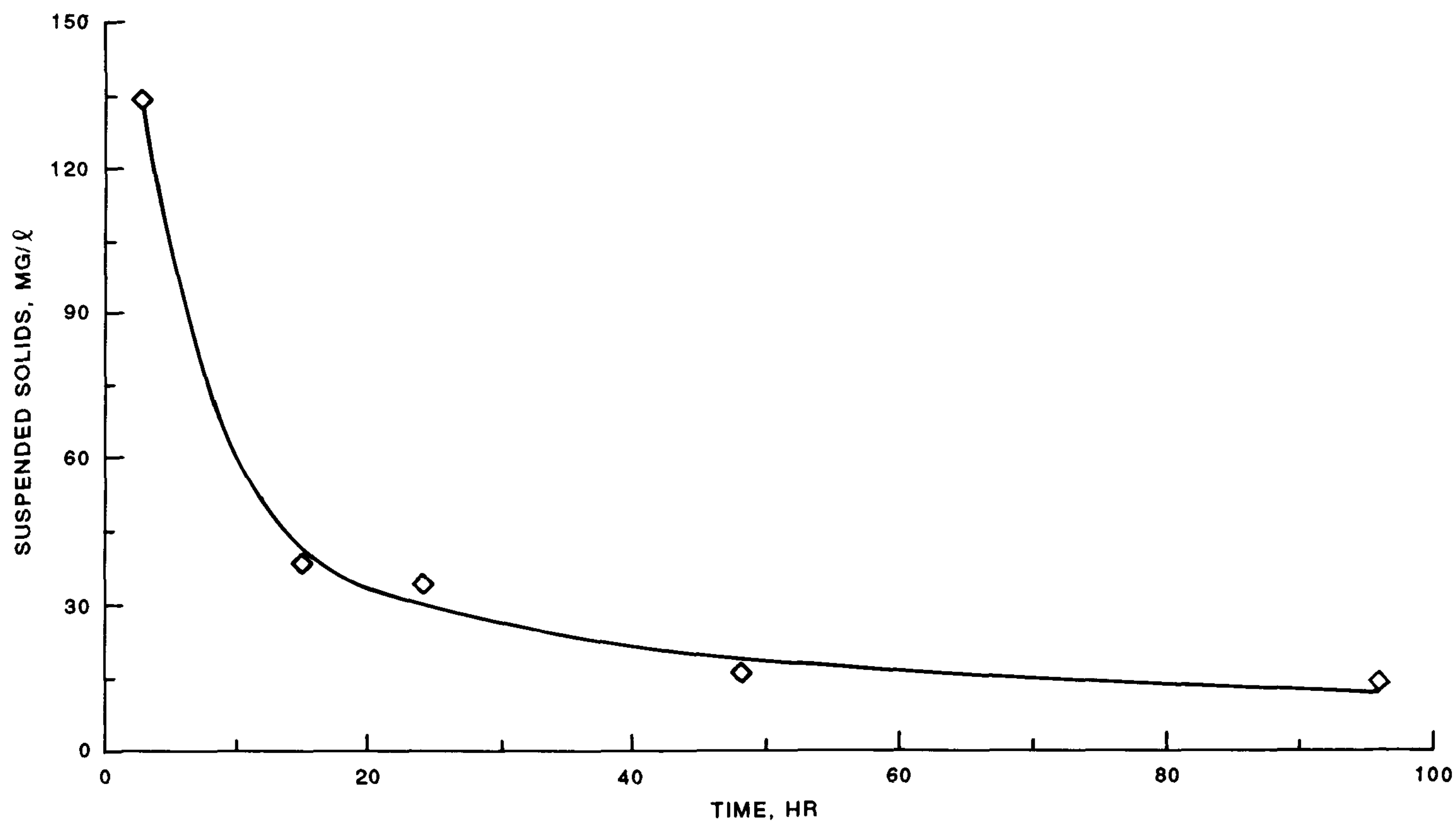


Figure 9. Suspended solids versus retention time for flocculent settling tests

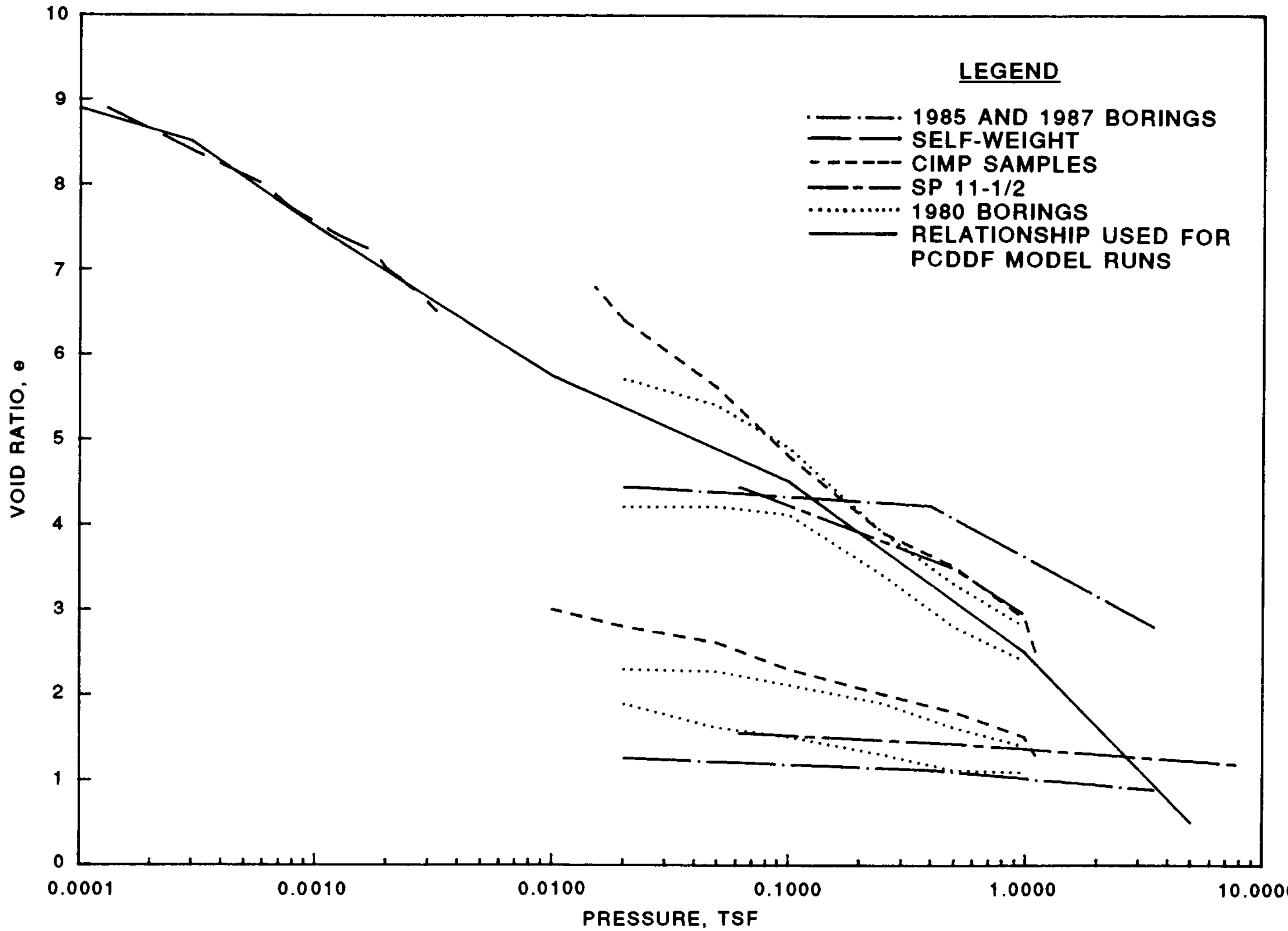


Figure 10. Consolidation test results for maintenance sediment

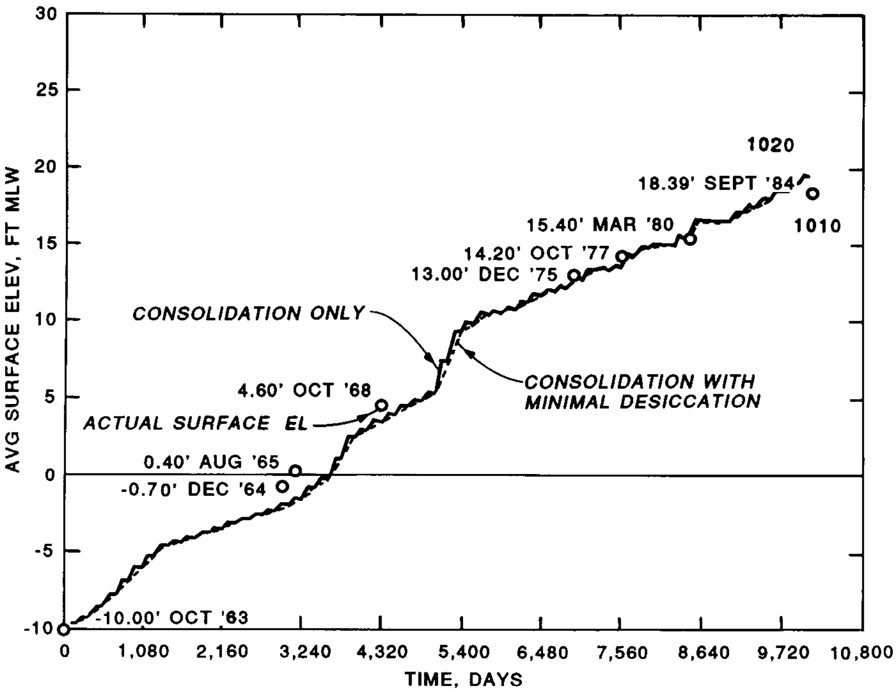
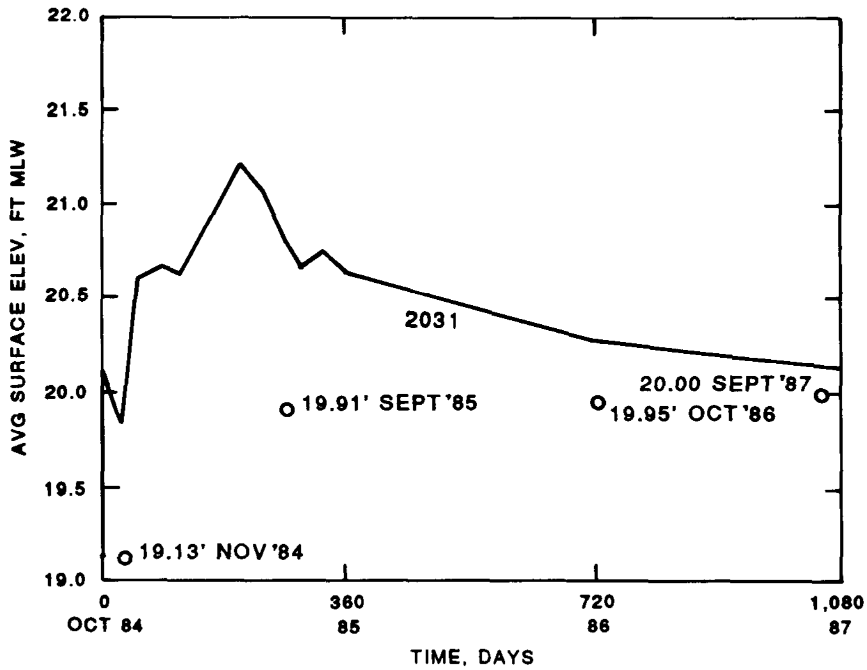
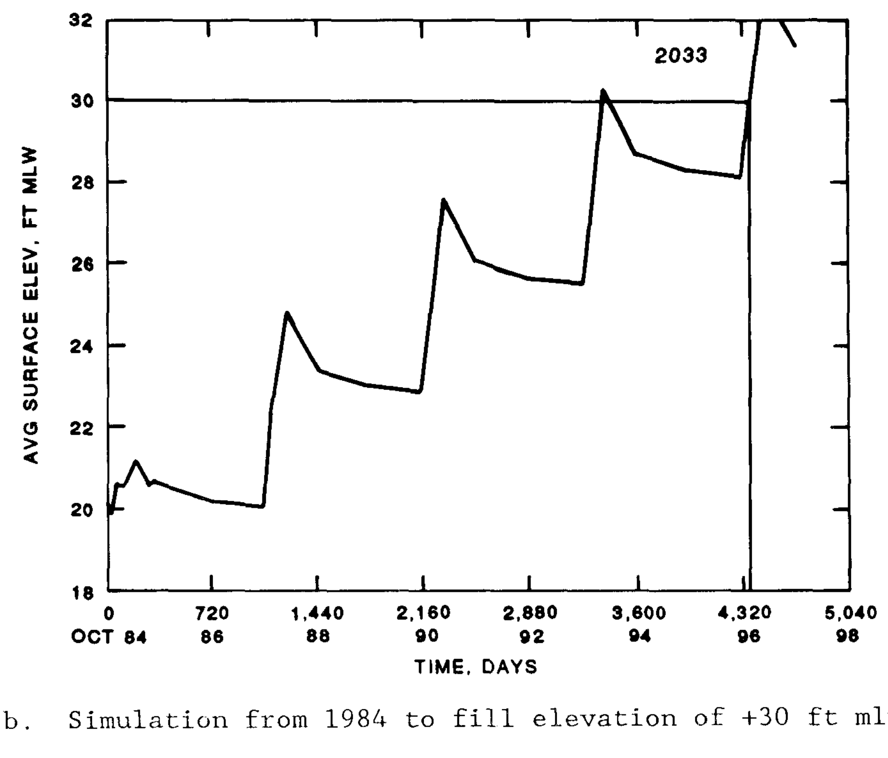


Figure 11. Simulation of fill rate, 1956-1984

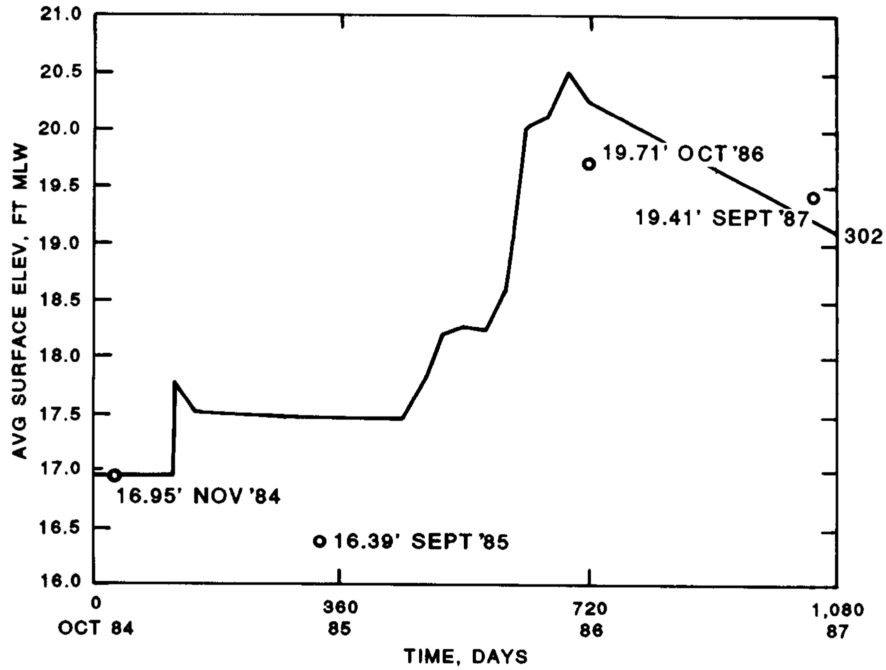


a. Simulation from 1984-1987

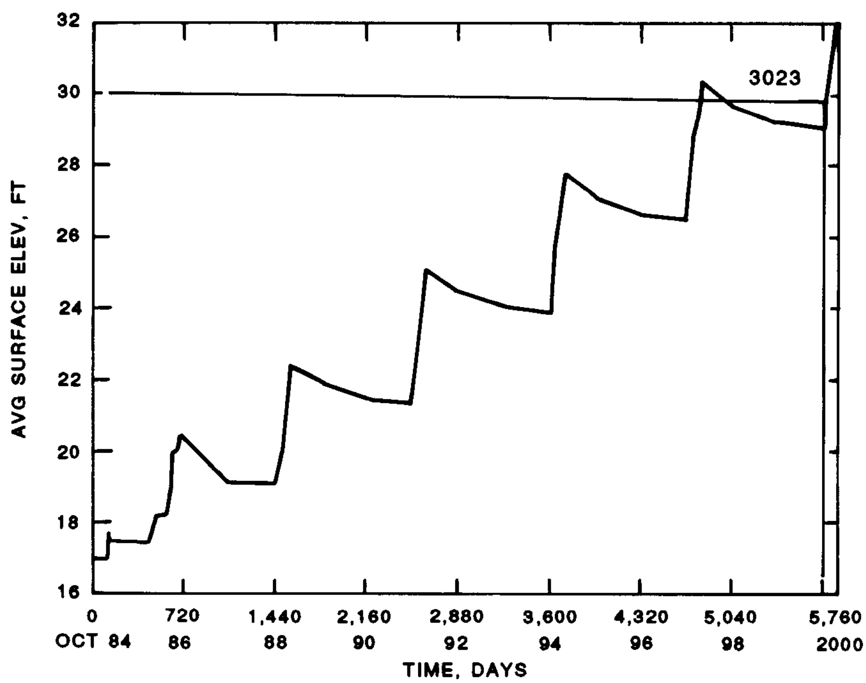


b. Simulation from 1984 to fill elevation of +30 ft mlw

Figure 12. Simulations of fill rates for north subcontainment

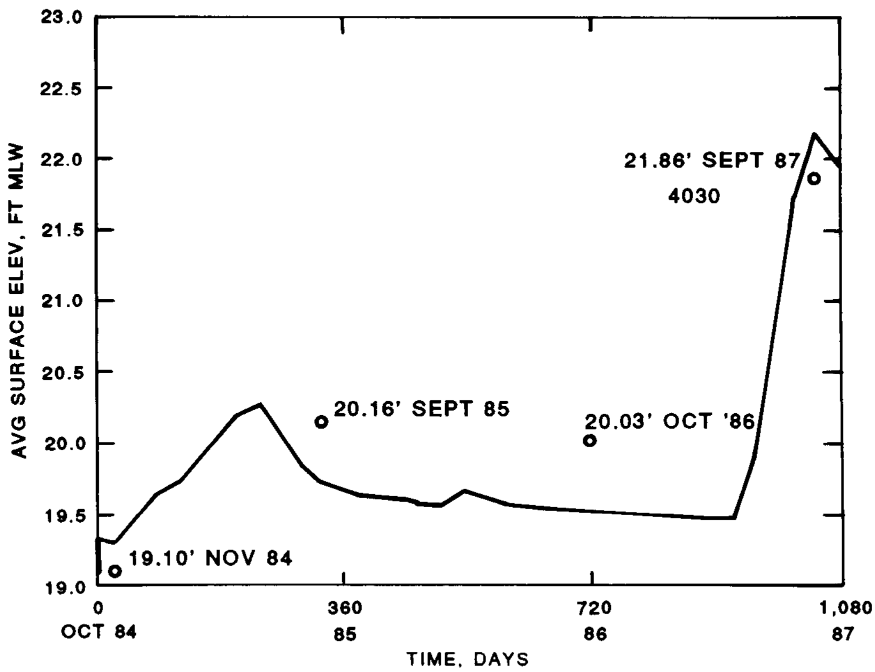


a. Simulation from 1984-1987

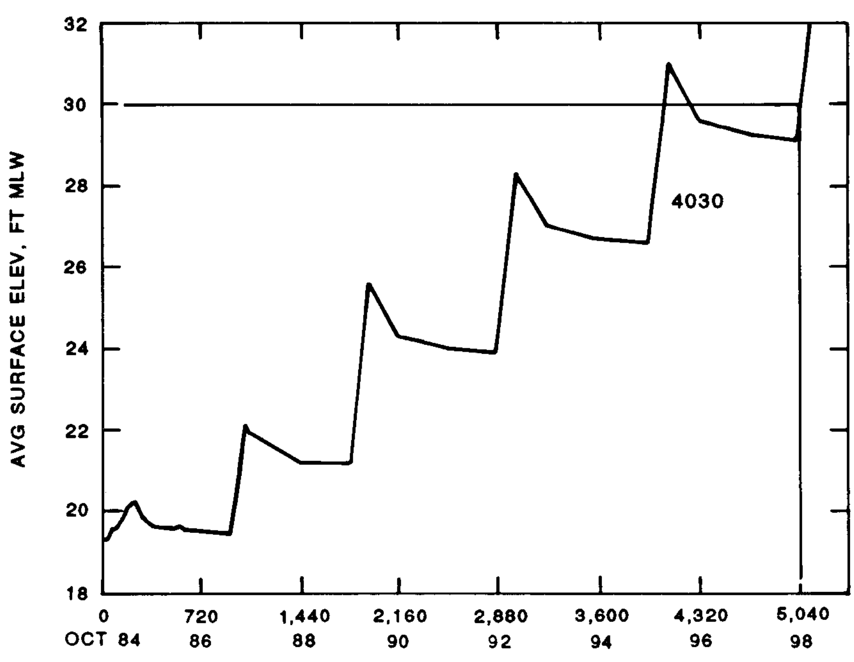


b. Simulation from 1984 to fill elevation of +30 ft mlw

Figure 13. Simulations of fill rates for center subcontainment

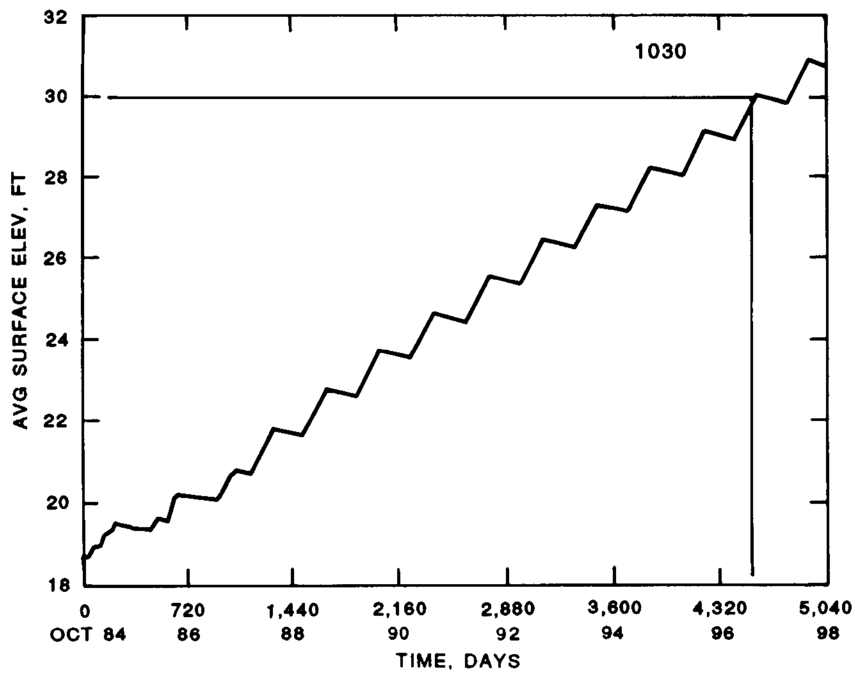


a. Simulation from 1984-1987

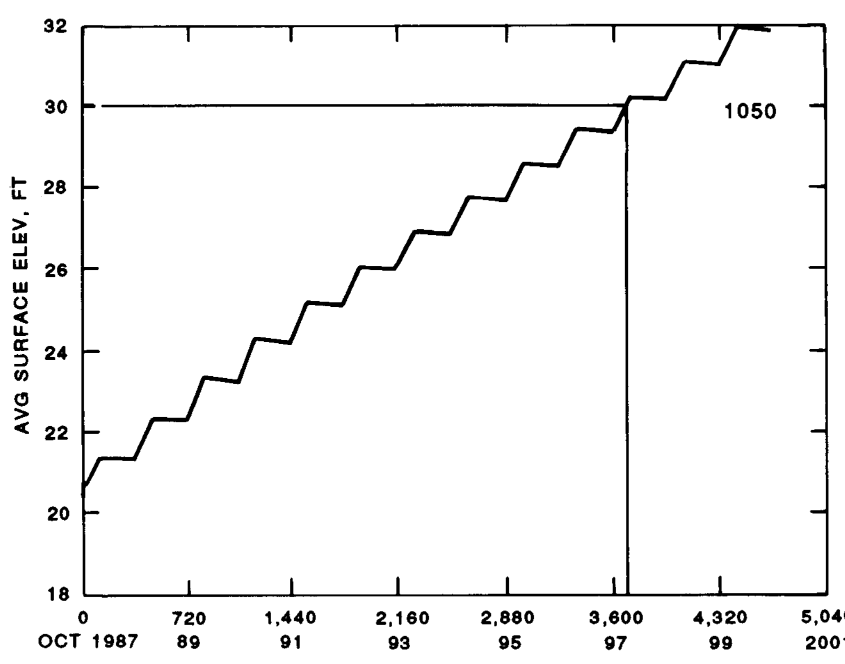


b. Simulation from 1984 to fill elevation of +30 ft mlw

Figure 14. Simulations of fill rates for south subcontainment



a. Simulation for 1984-1998, assuming no subdivision had taken place



b. Simulation for 1987 to fill elevation of +30 ft, assuming management discontinued in 1987

Figure 15. Simulations of fill rates with no management

APPENDIX A: CRANEY ISLAND DISPOSAL HISTORY

LOCATION & TYPE	DATES BEGIN	END	SUB*	USAED	OTHER FED	COMMERCIAL	YEARLY TOTAL	TOTAL DEPOSITS
PERMIT	Oct-56 -	Dec-56				982,566		
RE BASIN,NW	Jan-57 -	Aug-57		2,414,467				
RE BASIN,maint	Feb-57 -	May-57		302,243				
				2,716,710	0	982,566	3,699,276	3,699,276
NH,maint,HD	Oct-57 -	Nov-57		1,468,894				
NH,nw widen	Jul-58 -	Dec-58		4,708,210				
RE BASIN,maint	Jul-58 -	Sep-58		371,090				
				6,548,194	0	0	6,548,194	10,247,470
NH,SB,maint&nw	Jan-59 -	Apr-59		5,159,218				
NOB APPROACH	Jun-59 -	Aug-59			1,964,503			
RE BASIN,maint	Aug-59 -	Sep-59		940,351				
				6,099,569	1,964,503	0	8,064,072	18,311,542
NH,maint&nw	27-Oct-59 -	01-Jan-60		2,099,627				
CI ANCH,nw	25-Nov-59 -	22-May-60		4,643,020				
N&W PIERS A&B	10-Dec-59 -	27-Dec-59				127,630		
NAVY,DEGAUS	11-May-60 -	20-May-60			41,368			
				6,742,647	41,368	127,630	6,911,645	25,223,187
NH,SB,maint,HD	04-Oct-60 -	10-Nov-60		674,431				
RE BASIN,maint	20-May-61 -	20-Aug-61		1,042,693				
N&W PIERS,nw	02-May-61 -	30-Sep-61				687,634		
D&S PIERS,maint	01-Aug-61 -	17-Nov-61			317,673			
				1,717,124	817,673	687,634	3,222,431	28,445,618
N&W PIERS,nw	01-Oct-61 -	02-Mar-62				825,161		
S of N&W	24-Mar-62 -	02-Apr-62				119,740		
NH,maint, HD	03-Apr-62 -	25-Apr-62		1,258,530				
ESCI,barge reha	31-Aug-62 -	05-Sep-62				55,939		
CNN,maint,HD	05-Sep-62 -	22-Sep-62		766,893				
N&W PIERS,maint	14-Sep-62 -	10-Oct-62				156,645		
				2,025,423	0	1,157,485	3,182,908	31,628,526
NH,maint,HD	22-Sep-62 -	21-Oct-62		1,910,338				
NNSY	15-Oct-62 -	21-Oct-62			26,376			
RE BASIN,maint	05-Jan-63 -	01-Apr-63		795,559				
N&W PIERS	11-Feb-63 -	24-Feb-63				67,924		
NNSB	24-Feb-63 -	02-Mar-63				26,500		
NOB & D&S PIERS	02-Mar-63 -	13-Jun-63			521,419			
				2,705,897	547,795	94,424	3,348,116	34,976,642
NOB,maint	14-Jan-64	12-Mar-64			357,575			
NH,maint,HD	07-May-64	29-Jun-64		1,579,115				
RE BASIN,maint	02-Jun-64	30-Sep-64		603,878				
THIMBLE SHOALS,HD	23-Jun-64	02-Jul-64		63,920				
NOB,maint	27-Jul-64	12-Sep-64			371,275			
N&W,maint	10-Sep-64	02-Oct-64				148,853		
				2,246,913	728,850	148,853	3,124,616	38,101,258

* N = NORTH SUBCONTAINMENT, C = CENTER SUBCONTAINMENT, S = SOUTH SUBCONTAINMENT.

LOCATION & TYPE	DATES BEGIN	END	SUB#	USAED	OTHER FED	COMMERCIAL	YEARLY TOTAL	TOTAL DEPOSITS
RE BASIN,maint	01-Oct-64	05-Jan-65		603,878				
NH 40,maint,HD	03-Mar-65	02-Jun-65		2,618,550				
NNSY,maint,HD	14-May-65	22-May-65			107,900			
ESCI,BR	12-Jul-65	24-Jul-65				64,755		
NOB,maint	26-Jul-65	07-Oct-65			602,060			
HRSD,TP	03-Aug-65	31-Aug-65				1,096		
N&W,maint	11-Sep-65	12-Sep-65				4,770		
				3,222,428	709,960	70,621	4,003,009	42,104,267
N&W PIERS,maint	08-Oct-65	12-Oct-65				28,613		
NOB,D&S PIERS	10-Oct-65	07-Dec-65			466,515			
NH45maint,HD	03-Sep-65	01-Dec-65		2,333,940				
NH45,nw	23-Mar-66	30-Sep-66		2,931,330				
CI FUEL DEPOT	20-Aug-66	19-Nov-66			360,815			
				5,265,270	827,330	28,613	6,121,213	48,225,480
NH45,nw	01-Oct-66	16-Jan-67		1,465,600				
RE BASIN,maint	24-Sep-66	21-Apr-67		1,032,198				
NH45,nw	26-Oct-66	22-Dec-66		176,575				
NH40,maint,HD	29-Oct-66	19-Dec-66		1,197,650				
N&W,nw	20-Nov-66	11-Jan-67				281,960		
PMT,VPA,nw	17-Jan-67	17-Apr-67				1,004,959		
CNN45,nw	25-Mar-67	30-Sep-67		3,258,490				
NH45,nw	22-Apr-67	22-Aug-67		3,588,859				
C&O,NN,nw	27-Aug-67	22-Oct-67				420,710		
				10,719,372	0	1,707,629	12,427,001	60,652,481
CNN45,nw	01-Oct-67	11-Jan-68		1,629,245				
ATLAS CEMENT	15-Jan-68	20-Jan-68				46,590		
NP&IA	12-Jan-68	13-Feb-68				811,471		
NOB,maint	20-Feb-68	27-Apr-68			715,366			
NH45,maint,HD	26-Jan-68	08-Feb-68		236,247				
NH40,maint,HD	04-Feb-68	02-Mar-68		716,262				
NNSY,maint,HD	07-Feb-68	24-Feb-68			72,193			
NH45,maint	06-Apr-68	25-Jul-68		1,508,336				
CNN45,nw	08-Sep-68	01-Oct-68		230,630				
				4,320,720	787,559	858,061	5,966,340	66,618,821
NOB & D&S PIERS	14-Sep-68	28-Nov-68			538,103			
NH40&45,maint,HD	29-Jan-69	03-May-69		2,305,462				
CI FUEL DEPOT,nw	16-Feb-69	17-Apr-69			583,635			
CNN45,nw	13-May-69	30-Dec-69		1,898,300				
				4,203,762	1,121,738	0	5,325,500	71,944,321
D&S PIERS,maint	06-Nov-69	13-Feb-70			225,500			
NIT,VPA	06-Nov-69	18-Nov-69				115,925		
N&W,maint	23-Oct-69	05-Nov-69				180,967		
NNSY,maint,HD	02-Jan-70	03-Feb-70			71,200			
NH40&45,maint	02-Jan-70	10-May-70		1,978,980				
CNN,maint	10-May-70	16-May-70		188,610				
NP&IA	09-Jan-70	11-Feb-70				493,425		
RE BASIN,maint	07-Mar-70	11-May-70		800,407				
N&W,maint	30-Mar-70	19-May-70				112,476		
DEGAUS RANGE	24-May-70	25-Aug-70			327,401			
NOB,PIER 12	11-Jul-70	11-Aug-70			226,775			
N&W,maint	23-Sep-70	01-Oct-70				71,672		
NAVY POL,nw	01-Aug-70	22-Sep-70			525,138			
				2,967,997	1,376,014	974,465	5,318,476	77,262,797

LOCATION & TYPE	DATES BEGIN	END	SUB*	USAED	OTHER FED	COMMERCIAL	YEARLY TOTAL	TOTAL DEPOSITS
SPA,nw	31-Aug-70	30-Sep-71		8,039,700				
CNN,maint,HD	29-Sep-70	29-Oct-70		370,690				
NIT,VPA,maint	03-Oct-70	12-Oct-70				131,988		
NH40,maint	29-Oct-70	27-Nov-70		890,285				
NH45,maint	11-Dec-70	16-May-71		1,852,999				
EXXON PIERS	13-Mar-71	19-Mar-71				50,104		
NOB,maint	05-Apr-71	22-Jun-71			485,175			
NNA40,nw	16-Jul-71	22-Nov-71		4,828,174				
USCG,CI CR,nw	16-Aug-71	20-Nov-71			671,202			
				15,981,848	1,156,377	182,092	17,320,317	94,583,114
SPA,nw	01-Oct-71	01-Feb-72		2,679,887				
PMT,VPA,maint	16-Oct-71	14-Nov-71				322,389		
N&W,maint	20-Nov-71	09-Dec-71				166,698		
NH40&45,maint	02-Nov-71	04-Jan-72		1,489,000				
USCG,CI CR,maint	09-Feb-72	01-Aug-72			288,507			
RE BASIN,maint	25-Jun-72	19-Sep-72		892,487				
NOB & D&S PIERS	08-Aug-72	05-Sep-72			239,032			
ATLAS CEMENT	06-Sep-72	11-Sep-72				23,050		
NH45,maint	12-Sep-72	29-Oct-72		606,717				
				5,668,091	527,539	512,137	6,707,767	101,290,881
NIT,VPA,nw	27-Jan-73	03-May-73				1,264,045		
NH40,maint,HD	07-Feb-73	28-Mar-73		862,800				
CNN,maint,HD	23-Feb-73	28-Mar-73		238,060				
NNSY,maint,HD	17-Feb-73	22-Mar-73			57,950			
HRBT,VDOT,nw	27-Apr-73	05-May-73				183,406		
N&W,maint	09-May-73	23-May-73				152,170		
NNSB,maint	23-May-73	26-May-73				15,907		
C&O PIERS,maint	08-Jul-73	23-Jul-73				70,552		
NNSB,nw	07-Aug-73	30-Sep-73				324,976		
				1,100,860	57,950	2,011,056	3,169,866	104,460,747
NNSB,nw	02-Oct-73	31-Dec-73				956,776		
NOB&D&S,maint	10-Oct-73	01-Apr-74			916,855			
NH40&SB35,m,HD	13-Dec-73	29-Jan-74		852,544				
NNSY,maint,HD	19-Dec-73	29-Dec-73			54,823			
NNSB,nw	01-Jan-74	26-May-74				659,742		
NNSB,nw	01-Jan-74	26-May-74				769,928		
PMT,VPA	09-Jun-74	22-Aug-74				674,820		
NOB,maint	25-Jun-74	18-Sep-74			207,855			
D&S PIERS,maint	19-Jul-74	09-Sep-74			199,710			
				852,544	1,379,243	3,061,266	5,293,053	109,753,800
NIT,VPA,maint	08-Dec-74	24-Dec-74				199,174		
NH45,maint	29-Jan-75	16-Mar-75		1,622,300				
DEGAUS RANGE	15-Feb-75	23-Feb-75			36,825			
CARGILL GRAIN,BR	15-Feb-75	14-Mar-75				103,324		
NNSB,maint,BR	01-Mar-75	04-Mar-75				14,625		
YELLOW RIVER(LIM)	18-Mar-75	22-Mar-75				11,728		
NNSB,maint	22-Apr-75	30-May-75				263,948		
SO. BLOCK,SB	30-May-75	01-Jun-75				7,156		
US GYPSUM,SB	01-Jun-75	02-Jun-75				4,316		
NOB,maint	28-Jun-75	16-Sep-75			530,995			
RE BASIN,maint	07-Aug-75	17-Nov-75		770,254				
				2,392,554	567,820	604,271	3,564,645	113,318,445

LOCATION & TYPE	DATES : BEGIN	END	SUB*	USAED	OTHER FED	COMMERCIAL	YEARLY TOTAL	TOTAL DEPOSITS
NNSY,maint,HD	06-Oct-75	27-Oct-75			79,695			
NH40,maint,HD	03-Oct-75	30-Oct-75		476,270				
CNN,maint,HD	03-Oct-75	30-Oct-75		120,863				
NNSB,nw	10-Oct-75	14-Dec-75				433,649		
C&O COAL PIER,BR	14-Dec-75	18-Dec-75				26,532		
NH45,maint	18-Nov-75	21-Jan-76		539,132				
NOB,12,maint	08-Feb-76	13-Mar-76			386,425			
N&W,maint	07-Mar-76	06-Apr-76				102,916		
NORSHIPCO	07-Apr-76	06-Jul-76				334,220		
NOB,25,nw&m	03-Jun-76	03-Jul-76			622,180			
VDOT,W NOR.BR	29-May-76	15-Jul-76				12,924		
NH45,maint	17-Jul-76	04-Oct-76		2,455,287				
N & W,maint	25-Aug-76	24-Sep-76				384,679		
NOB,BOAT BASIN	27-Jul-76	17-Sep-76			67,200			
				3,591,552	1,155,500	1,294,920	6,041,972	119,360,417
NNSB,maint	28-Nov-76	03-Jan-77				110,307		
NNSB,WAY5&6,m	23-Nov-76	30-Nov-76				37,205		
C&O COAL PIER	14-Feb-77	20-Feb-77				20,045		
VDOT,JRB	14-Feb-77	20-Feb-77				6,071		
NNSY,maint,BR	08-Feb-77	23-Feb-77			39,645			
NOB,20,maint	12-Feb-77	04-May-77			528,325			
NNSB,nw,BR	26-Apr-77	17-Jun-77				333,900		
SPA,maint	05-May-77	20-Jun-77		743,476				
VDOT,JRB	06-May-77	21-May-77				5,528		
WILLOUGHBY BAY	18-May-77	20-May-77		2,400				
DEGAUS RANGE	21-May-77	21-Jun-77			130,480			
DEEP CR,NN,m,BR	25-Jun-77	15-Jul-77		42,862				
				788,738	698,450	513,056	2,000,244	121,360,661
NORSHIPCO	01-Oct-77	25-Jan-78				222,230		
NNSB,W EXT,nw	17-Dec-77	31-Dec-77				53,646		
NOB,2&4,maint	30-Jan-78	21-Feb-78			211,245			
RE BASIN,maint	21-Feb-78	05-Jan-79		1,231,637				
NH40&SB35,m,HD	02-Mar-78	29-Mar-78		303,786				
NIT,VPA,nw	15-Mar-78	13-Aug-78				954,180		
CNN,maint,HD	16-Mar-78	01-Apr-78		129,160				
CNG,nw,BR	21-Mar-78	14-May-78				108,389		
NOB,12,maint	04-Apr-78	01-Jun-78			345,990			
NOB,12,nw	04-Apr-78	01-Jun-78			146,090			
FUEL LINE TRENCH	12-May-78	11-Jun-78			8,458			
C & O PIER14,BR	24-May-78	10-Jun-78				59,400		
NIT,VPA,maint	03-Jun-78	07-Jul-78				457,370		
NH45,maint	06-Jun-78	01-Nov-78		2,147,368				
ERT,maint,BR	12-Jun-78	15-Jun-78				2,250		
PMT,VPA,nw	15-Jun-78	17-Nov-78				601,176		
				3,811,951	711,783	2,458,641	6,982,375	128,343,036
EXXON PIER	15-Oct-78	24-Oct-78				76,091		
NOB,PIER24,nw	12-Dec-78	14-Feb-79			475,435			
NOB,D&S PIERS	06-Jan-79	20-Mar-79			337,630			
YORKTOWN NWS,HD	02-Jan-79	06-Mar-79			400,971			
NIT,VPA,maint	15-Jul-79	29-Jul-79				111,255		
				0	1,214,036	187,346	1,401,382	129,744,418

LOCATION & TYPE	DATES BEGIN	END	SUB*	USAED	OTHER FED	COMMERCIAL	YEARLY TOTAL	TOTAL DEPOSITS
VDOT,JRB,nw	16-Oct-79	24-Oct-79				9,068		
DEEP CR,NN,maint	25-Oct-79	18-Jan-80		296,375				
SPA,maint	15-Aug-79	18-Nov-79		1,477,626				
NH45,maint	10-Nov-79	18-Jun-80		2,016,563				
NOB,PIERS,m	21-Nov-79	22-Feb-80			204,007			
NNA,maint	12-Apr-80	29-May-80		1,087,166				
NOB,3-7,22,25m	21-Apr-80	18-Jun-80			407,375			
CONT GRAIN,nw&m	17-Jun-80	06-Aug-80				159,350		
N&W,nw&m	07-Jul-80	02-Aug-80				230,354		
NOB,12,maint	12-Aug-80	03-Sep-80			251,738			
RE BASIN,maint	20-Feb-80	14-Oct-80		1,637,381				
NOB,7,maint	04-Sep-80	06-Sep-80			25,092			
NIT,VPA,maint	19-Feb-80	22-Feb-80				14,823		
				6,515,111	888,212	413,595	7,816,918	137,561,336
NOB,AFDL,maint	12-May-81	05-Jul-81			247,155			
NOB PIERS,maint	23-Jul-81	14-Nov-81			651,882			
CI FUEL DEPOT,m	14-Sep-81	14-Oct-81			35,997			
				0	935,034	0	935,034	138,496,370
NH45,maint	14-Sep-81	22-Jan-82		2,228,076				
N&W,maint	19-Nov-81	01-Dec-81				96,024		
RE BASIN,maint	09-Jan-82	30-Sep-82		1,414,988				
CNN maint	24-Apr-82	23-Jun-82		648,722				
DOMINION TER,nw	25-Jul-82	30-Sep-82				330,000		
NOB,maint	22-Jan-82	19-Mar-82			891,629			
				4,291,786	891,629	426,024	5,609,439	144,105,809
RE BASIN,maint	01-Oct-82	08-Jun-83		1,414,988				
DOMINION TER,nw	01-Oct-82	09-Jun-83				989,925		
NH45,maint	14-Nov-82	24-May-83		2,183,692				
NOB PIERS,maint	28-Sep-82	11-Apr-83			366,479			
NOB,ADFL,maint	03-May-83	24-May-83			114,005			
NIT,VPA,maint	12-Jun-83	05-Jul-83				392,148		
				3,598,680	480,484	1,382,073	5,461,237	149,567,046
NOB PIERS,maint	19-Oct-83	26-Nov-83	N		363,098			
RE BASIN.maint	01-Apr-84	30-Sep-84	S	869,433				
NH45,maint	06-Apr-84	30-Sep-84	N	1,752,340				
NOB PIER 11,m	22-May-84	06-Jul-84	N		469,639			
SPA,maint	04-Feb-84	29-Sep-84	N	2,451,377				
				5,073,150	832,737	0	5,905,887	155,472,933
RE BASIN,maint	01-Oct-84	16-May-85	S	1,391,094				
NH45,maint	01-Oct-84	14-Dec-84	N	876,171				
NOB PIERS,maint	16-Sep-84	28-Nov-84	N		775,448			
N & W,maint	23-Oct-84	24-Nov-84	N			121,457		
NIT,maint&nw	03-Feb-85	02-Apr-85	C			600,095		
NNA,maint,HD	02-Feb-85	07-Mar-85	N	183,546				
NOB PIERS,maint	07-Mar-85	01-May-85	N		610,386			
EXXON PIER,maint	16-May-85	22-May-85	N			77,150		
LEHIGH CEMENT,m	22-May-85	24-May-85	N			45,400		
NNA,maint	31-Jul-85	11-Aug-85	N	251,987				
				2,702,798	1,385,834	844,102	4,932,734	160,405,667

LOCATION & TYPE	DATES BEGIN	END	SUB*	USAED	OTHER FED	COMMERCIAL	YEARLY TOTAL	TOTAL DEPOSITS
VDOT,I-664,nw	07-Jan-86	19-Mar-86	C			997,142		
WB ELIZ R,maint	02-Feb-86	22-Mar-86	S	150,431				
NIT,nw	22-May-86	22-Jun-86	C			1,618,841		
NOB PIERS,maint	01-Jun-86	29-Jun-86	C		185,365			
NH40,maint	15-Jul-86	14-Aug-86	C	192,055				
NH45,maint	15-Jul-86	30-Aug-86	C	529,325				
				871,811	185,365	2,615,983	3,673,159	164,078,826
NOB PIERS,nw	09-Jun-87	01-Aug-87	S		978,250			
NOB PIERS,nw	20-Jul-87	08-Aug-87	S		153,474			
RE BASIN,maint	08-May-87	23-Aug-87	S,C	1,681,024				
				1,681,024	1,131,724	0	2,812,748	166,891,574
				120,424,524	23,122,507	23,344,543		166,891,574

APPENDIX B: ANTICIPATED VERSUS ACTUAL FILL RATES, 1980-1987

Background

1. In 1979, the Craney Island disposal site had been filled to an average elevation of approximately +15 ft, and it was recognized that the remaining life of the site was limited. The development of the Craney Island Management Plan (CIMP) included projections of site life both with and without subdivision and management for dewatering. Since 1984, the site has been subdivided and managed for dewatering; however, the fill rate has been faster than hoped for based on projections in the CIMP. This appendix discusses the anticipated versus actual fill rates for the Craney Island site.

Projected Fill Rates

CIMP projections

2. A number of projections of fill rate were made for the CIMP using a mathematical model for dredged material consolidation called PROCON (Johnson 1976*), which had been modified to account for the added effect of dredged material desiccation. The filling history was simulated from 1953 to 1979 to calibrate the model. Projections of the fill rate for a 25-year period were then made for the conditions of (a) no subdivisions and no management (continuation of the previous method of operation), (b) subdivision and management of surface water, and (c) subdivision and management for active dewatering. Further, the alternatives were compared for 2-, 3-, 4-, and 6-subcontainment configurations. The results of these projections indicated a benefit associated with subdivision and management of surface water, and an even more dramatic benefit associated with active dewatering. The CIMP recommended subdivision of the site into three subcontainments (partially because of the construction effort already expended toward that configuration) and the implementation of a management program for dewatering through a surface trenching approach.

3. The CIMP also presented projections of the anticipated fill rate to an elevation of +30 ft for the conditions of no management and implementation of subdivision and management as recommended. With 1979 as a starting point, the site was projected to fill to +30 ft by 1998 (19 years) for the no-management operation. With subdivision and management for dewatering, the

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* See References at the end of the main text.

site was projected to fill to +30 ft by the year 2016 (36 years). The additional life of 17 years is equivalent to 89 percent of the projected remaining capacity with no management.

4. It should be noted that the above projections of gain in capacity were developed with the assumption of a 100 percent-efficient dewatering program. The CIMP (page 164) states:

> Implementation of an active dewatering program will increase desiccation, significantly adding to storage capacity. Model projections indicate a disposal area life of approximately 36 years using a 100 percent efficient surface drainage system (until an average surface elevation of +30 ft is reached), representing practically double that estimated for the present [1979] mode of operation. Actual benefits will probably be less due to inefficiencies of the drainage system.

Current projections

5. The site was subdivided in 1984, and the management program was generally implemented. Projections of site life in Part IV of the main text indicate that the site would be filled during FY 97 if the site had never been subdivided (12 years with October 1984 as a starting point). With management from October 1984 through October 2000, the life would increase by approximately 3 years. This represents a gain in capacity of 25 percent of the projected remaining capacity with no management.

Analysis of Anticipated Versus Actual Fill Rates

6. The differences between the optimistic projection of management benefits in the CIMP (89 percent) versus those currently indicated by the monitoring data (25 percent) are substantial. This difference can be related to factors concerning accuracy of long-term projections and the fact that dewatering processes acting at the Craney Island site are less than 100-percent efficient. Factors that could account for the difference include the following:

a. Inaccuracies of the models used for the projections.

b. Inaccuracies of assumed conditions.

c. Inefficiency of surface trenching systems for drainage.

d. The elapsed time before initiation of management.

e. Inefficient rotation of disposal between subcontainments.

f. Incomplete trenching systems.

g. Reduced surface area available for disposal.

h. Greater than anticipated annual dredging volumes.

i. Placement of new work material.

Each of these factors is discussed in the following paragraphs.

Inaccuracies of models

7. Projections of site life for the CIMP were made using the best available models at the time. The PROCON model was a small strain theory consolidation model that had been modified to account for additional settlements due to dredged material consolidation. In making the modifications, the effect of desiccation was assumed to be additive. This assumption resulted in great differences in settlements when desiccation was considered. More recent work on the theory of dredged material desiccation processes (Cargill 1983, 1985) has indicated that consolidation and desiccation settlements are not purely additive, but depend on interaction between the processes. Further, the effects of desiccation are not constant throughout the period of desiccation but decrease in a nonlinear fashion with increases in the crust thickness. The more recent Primary Consolidation and Desiccation of Dredged Fill (PCDDF) model has accounted for these processes. A detailed comparison of the original CIMP projections using the PROCON and PCDDF models was conducted and is described in Appendix C. The predictions of settlements from the combined effect of consolidation and desiccation using the PCDDF model are much lower than corresponding predictions using the PROCON model. Also, long-term projections of such complex material behavior are subject to potential errors with any model.

Inaccuracies in assumed conditions

8. If the model algorithms matched field processes perfectly, model predictions could still be in error if input data on material properties or climatic conditions did not correspond with the field conditions. Consolidation and drying properties are necessarily based on a limited number of laboratory tests, and many assumptions on precipitation rates, evaporation rates, filling rates, etc., are required for the projections. Any error due to an inaccuracy in assumed conditions is compounded in projections of long-term behavior.

Inefficiency of surface trenches

9. The CIMP projections of an 89-percent gain in capacity were based on a 100 percent-efficient surface drainage system. This means that 100 percent

of all rainfall was assumed to be carried offsite prior to any infiltration, and the evaporative forces were assumed to be 100 percent efficient in removing water from the dredged material throughout the dewatering period. If the current projections are accurate, the degree of management now implemented at the site is approximately 28 percent efficient (25 percent/89 percent). Monitoring the relative runoff behavior for a trenched and untrenched subcontainment (as recommended in the Monitoring Plan) would more clearly define the efficiency of the trenching systems that are now being constructed.

Time of implementation of management

10. The site was subdivided and management initiated in 1984, 4 years into the originally projected 19-year life with no management. This consumed roughly 20 percent of the capacity before any increase could possibly be realized. Although this delay should not affect the benefits of management expressed as percent of current remaining life, the overall filling rate was affected.

Actual versus
recommended rotation of flow

11. The rotation of disposal between subcontainments since 1984 has not been in strict accordance with the CIMP recommendation of yearly rotation. In all years since 1984, material has been disposed in more than one cell. This is due primarily to scheduling problems of dredging contracts and fears of claims from contractors due to longer pumping distances. In one instance the diversion of flow to another subcontainment was necessary due to a high flow rate. When flow is diverted, even for a short period, a layer of material of high water content is placed over a drier material that has been undergoing drying. Since a pond must be maintained for efficient settling, the infiltration of water into the drier material could be substantial. Once the diversion is stopped and the pond decanted, a period of several months may be required for excess water to be removed from the newly placed layer and for desiccation to begin anew. Then, once the desiccation process begins, the evaporative energy is expended on the new layer, not on the underlying layer that was undergoing drying prior to the diversion. Although the CIMP did indicate that temporary diversion of flow to other than the intended subcontainment may be necessary, the anticipated benefits of management assumed that the full 2-year inactive period would be available for dewatering.

Incomplete construction of trenching systems

12. Trenching for dewatering has not been fully implemented to the degree and at the schedule called for in the CIMP. This has been due to diversion of material to more than one cell in a given year and maintenance and mobility problems with the rubber-tired trencher. Breakdowns of the rotary trencher are frequent. No spare parts are now being kept on hand, so long delays result. Also, when breakdowns occur, access to the equipment for repair is a major effort due to the size of the subcontainments. Further, onsite government personnel cannot be fully dedicated to the trenching work because of other requirements. The mobility problems with the trencher occur when it must cross riverine utility craft tracks that were constructed soon after dewatering begins. Retrieval of the trencher with cable from the dikes in the large cells is a major task, and the operations crew is reluctant to begin trenching with the rubber-tired equipment at an early stage.

Surface area available for placement

13. A surface area available for disposal of 753 acres for each subcontainment was assumed for projections of capacity in the CIMP. However, the available surface areas of the subcontainments are now 658, 720, and 702 acres for the north, center, and south subcontainments, respectively. The subdivision dikes have a large width due to the fabric section originally placed for their initial construction. This has possibly reduced the surface area of the cells over that originally projected, causing greater lift thicknesses for a given dredged volume and less efficient dewatering.

Dredged volumes

14. The CIMP life projections were based on a 5-million cubic yard per year anticipated fill rate. Even though the average fill rate since 1980 has been roughly equivalent to this, several years of filling have exceeded this volume by roughly 50 percent, causing higher lift thickness and reduced potential for dewatering for those lifts.

Placement of new work material

15. The CIMP projections were made assuming only maintenance material would be placed in the site; however, a considerable volume of new work material has been placed in the site, and more is anticipated. Material properties for new work material are considerably different from those for maintenance. The higher in situ density of new work material means that a proportionally larger volume will be occupied in the site as compared with

that which would be occupied by the same in situ volume of maintenance material.

APPENDIX C: COMPARISON OF MODEL PROJECTIONS

Introduction*

1. This appendix presents comparisons of filling simulations for management options contained in the Craney Island Management Plan (CIMP) (Palermo, Shields, and Hayes 1981**) with simulations using the Primary Consolidation and Desiccation of Dredged Fill (PCDDF) model. The alternative management options consisted of:

   a. Disposal of dredged material onto a single large containment area without surface water control, thereby precluding enhanced settlement due to desiccation.

   b. Subdivision of the containment area into two, three, four, or six subareas, alternating disposal into each subarea and providing surface water control.

   c. Subdivision of the containment area into two, three, four, or six subareas, alternating disposal into each subarea, providing surface water control and implementing active dewatering procedures.

2. Data from the Craney Island disposal area were used, and the results were compared with an earlier evaluation of the same alternative management options presented in the CIMP (Palermo, Shields, and Hayes 1981). The results were also compared with a previous PCDDF simulation of the 24-year filling period conducted in 1984. This evaluation utilized the version of PCDDF modified to execute on the IBM microcomputer.

Simulation Results

Input data

3. Material characteristics, disposal sequences, climatic information, and desiccation characteristics used for the evalution were those presented in the earlier reports. The consolidation properties of the compressible foundation and the dredged fill as well as the desiccation properties of the dredged fill were obtained from the previous (1984) PCDDF simulation. The input parameters used in the verification and the disposal alternatives relating to desiccation are presented in Table C1.

Verification of parameters

4. Disposal records and topographic survey information were

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* This appendix was prepared by Mr. Gary F. Goforth, University of Florida.
** See References at the end of the main text.

incorporated to verify the accuracy of the simulation input parameters. Results are presented in Table C2 and Figure C1. The observed differences between the simulated surface elevations and the survey elevations may be due to inaccurate sequencing of the dredged material disposal. For consistency, it was assumed that the total annual disposal occurred during the month of June. As demonstrated, the simulated results are within a lift thickness of each survey elevation. As shown in Figure C2, there is a slight disagreement between the present and prior PCDDF simulations.

Management alternatives

5. Tables C3 and C4 and Figures C3-C5 present the simulation results of the various disposal scenarios. As with the verification run, disposal of the dredged fill was considered as a pulse input during the month of June. Table C3 and Figure C6 compare the results with those obtained from the CIMP using the settlement algorithm in PROCON. Surface elevations for Alternatives 1 and 2 are similar for both PROCON and PCDDF, with PCDDF consistently predicting less material settlement than PROCON. The estimated remaining storage life of the containment area for Alternative 1 as predicted by both algorithms was similar (within 2 years). Although predicted surface elevations after approximately 25 years were within 1 ft, estimates of remaining storage life for Alternative 2 as predicted by PCDDF were up to 4 years less than estimates provided by PROCON.

6. Significant differences in the surface elevation estimates at the end of 25 years for Alternative 3 were observed between PCDDF and PROCON. Along with the difference in absolute elevation, the two methods produced conflicting trends regarding the relationship between elevation and lift thickness/disposal frequency. Both methods use empirical algorithms to calculate settlement due to dewatering. The differences can be attributed to differences in the assumptions underlying the respective methods, in particular the inability of PCDDF to handle material removal (e.g., for dike maintenance). Estimates of remaining storage life based on PCDDF are significantly lower than those provided by PROCON, ranging from 6 years less for two subcompartments to 17 years less for four subareas. Results from PCDDF suggest that drying periods greater than 1 year do not enhance surface settlement. This is consistent with field observations of almost negligible settlement once a stable surface crust appears. By that time, the evaporation process is limited by the (mainly diffusive) vapor transport to the material surface.

Summary

7. The results of this evaluation may be summarized as follows:

   a. The verification of the input parameters was satisfactory.

   b. Storage life estimates produced by PCDDF were within 2 years of those produced by PROCON for Alternative 1.

   c. Storage life estimates produced by PCDDF were within 4 years of those produced by PROCON for Alternative 2.

   d. Storage life estimates produced by PCDDF were 6 to 17 years less than those produced by PROCON for Alternative 3.

   e. Both PROCON and PCDDF incorporate empirical algorithms to calculate surface settlement due to dewatering; their application should be limited to disposal operations that are consistent with their underlying assumptions.

Table C1

PCDDF Input Parameters Related to Dewatering

Parameter	Scenario			
	Verification	Alternative 1	Alternative 2	Alternative 3
Initial uniform void ratio	9.00	9.00	9.00	9.00
Void ratio at saturation limit	6.50	6.50	6.50	6.50
Void ratio at desiccation limit	3.20	3.20	3.20	3.20
Areal coverage by cracks	0.20	0.20	0.20	0.20
Maximum crust thickness, in.	6.00	6.00	6.00	18.00
Surface drainage efficiency	0.10	0.10	1.00	1.00
Pan evaporation coefficient	0.10	0.10	0.10	1.00

Table C2

Verification of Dredged Material Surface Elevation

Elapsed Time years	Lift Thickness ft	Survey Elevation ft msl	Simulation Results, ft msl		
			PROCON	PCDDF	PCDDF (1984)
0	0.311	-10.00	-10.00	-10.00	-10.00
1	1.326		-9.8		
2	1.609		-8.80	-8.80	
3	3.260		-7.50	-7.76	
4	1.698		-5.00	-5.68	-4.10
5	1.069		-3.25	-4.74	-3.75
6	1.360		-2.50	-4.15	-3.33
7	0.447		-1.50	-3.20	-2.90
8	0.181		-1.25	-2.96	-2.10
9	1.973	-0.80	0.00	-2.35	-1.00
10	2.032		1.25	-1.05	0.50
11	3.464	0.24	2.50	0.23	2.50
12	1.544		4.75	2.22	3.00
13	1.682	4.50	5.50	3.08	3.20
14	1.561		6.25	3.96	3.33
15	6.521		7.50	5.20	5.00
16	0.647		12.25	9.42	10.00
17	1.327		11.50	9.40	10.00
18	1.419		12.50	9.86	10.50
19	1.597		13.30	10.71	11.00
20	1.430	12.75	14.00	11.55	12.00
21	0.674		14.50	12.41	12.00
22	2.155	14.00	14.50	12.54	12.50
23	0.420		15.50	13.78	13.75
24		15.00	15.00	13.90	15.00

Table C3

Simulation Results (24.5 Years)

Scenario	Subarea	Fill Depth ft	PROCON Surface ft msl	PROCON Storage Life years	PCDDF Surface ft msl	PCDDF Storage Life years
Alternative 1	1	1.4	33.30	19	35.45	17
Alternative 2	2	2.8	31.80	22	31.80	21
	3	4.2	31.00	24	31.70	20
	4	5.6	30.60	23	31.60	19
	6	8.4	31.00	22	31.60	18
Alternative 3	2	2.8	25.40	31	28.07	25
	3	4.2	22.60	38	28.74	23
	4	5.6	21.20	40	29.20	23
	6	8.4	20.70	32	29.79	21

Table C4

Average Surface Elevations (ft msl) for Projected Filling Operations Using PROCON and PCDDF Models

Year*	Alternative 1	Alternative 2				Alternative 3			
		2**	3	4	6	2	3	4	6
0	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00	15.00
0	*16.40*	*17.80*	*19.20*	*20.60*	*23.40*	*17.80*	*19.20*	*20.60*	*23.40*
1	15.88								
1	*17.28*								
2	16.74	16.42							
2	*18.14*	*19.22*							
3	17.60		17.19				16.76		
3	*19.00*		*21.39*				*20.96*		
4	18.44	18.04		18.00		17.17		17.20	
4	*19.84*	*20.84*		*23.60*		*19.97*		*22.80*	
5	19.28								
5	*20.68*								
6	20.13	19.49	19.43		19.48	18.12	18.37		18.67
6	*21.53*	*22.29*	*23.63*		*27.88*	*20.92*	*22.57*		*27.07*
7	20.98								
7	*22.38*								
8	21.83	20.93		20.88		19.08		19.60	
8	*23.23*	*23.73*		*26.48*		*21.88*		*25.20*	
9	22.68		21.60				20.05		
9	*24.08*		*25.80*				*24.25*		
10	23.53	22.34				20.11			
10	*24.93*	*25.14*				*22.91*			
11	24.38								
11	*25.78*								
12	25.23	23.75	23.74	23.70	23.76	21.16	21.77	22.01	22.45
12	*26.63*	*26.55*	*27.94*	*29.30*	*32.16*	*23.96*	*25.97*	*27.61*	*30.85*
13	26.08								
13	*27.48*								
14	26.93	25.12				22.22			
14	*28.33*	*27.92*				*25.02*			
15	27.78		25.80				23.49		
15	*29.18*		*30.00*				*27.69*		
16	28.63	26.48		26.43		23.53		24.39	
16	*30.03*	*29.28*		*32.03*		*26.33*		*29.99*	
17	29.48								
17	*30.88*								
18	30.33	27.80	27.81		27.85	24.68	25.23		26.12
18	*31.73*	*30.60*	*32.01*		*36.25*	*27.48*	*29.43*		*34.52*
19	31.18								
19	*32.58*								
20	32.03	29.12		29.04		25.81		26.80	
20	*33.43*	*31.92*		*34.64*		*28.61*		*32.40*	
21	32.88		29.72				26.98		
21	*34.28*		*33.92*				*31.18*		
22	33.73	30.44				26.94			
22	*35.13*	*33.24*				*29.74*			
23	34.58								
23	*35.98*								
24	35.43	31.76	31.69	31.62	31.55	28.07	28.74	29.20	29.79
24	*36.83*	*34.56*	*35.89*	*37.22*	*39.95*	*30.87*	*32.94*	*34.80*	*38.19*

* For each year, two sets of projections are given: PROCON (in roman type) and PCDDF (in italics).

** Subarea number.

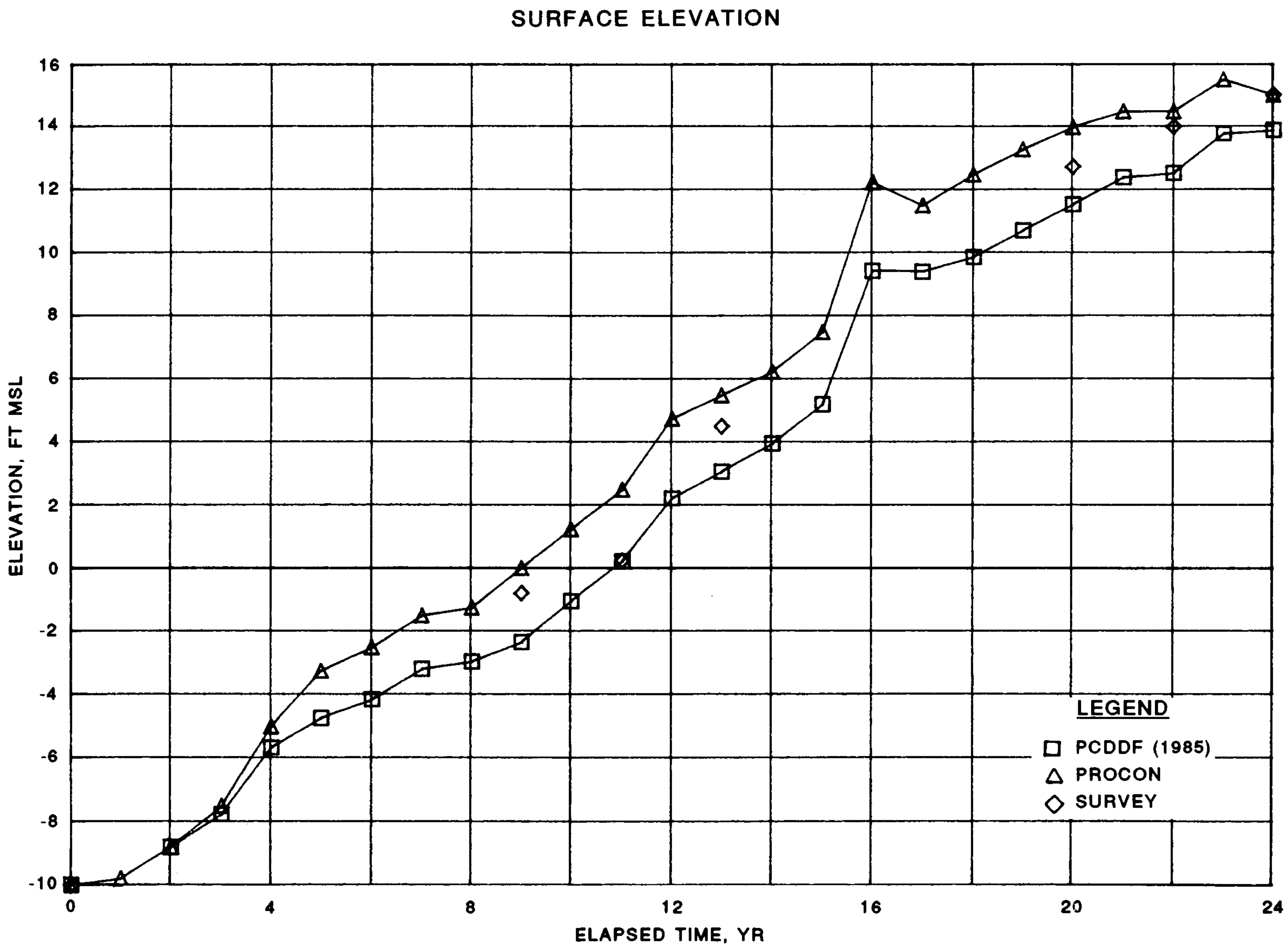

Figure C1. Verification of input parameters

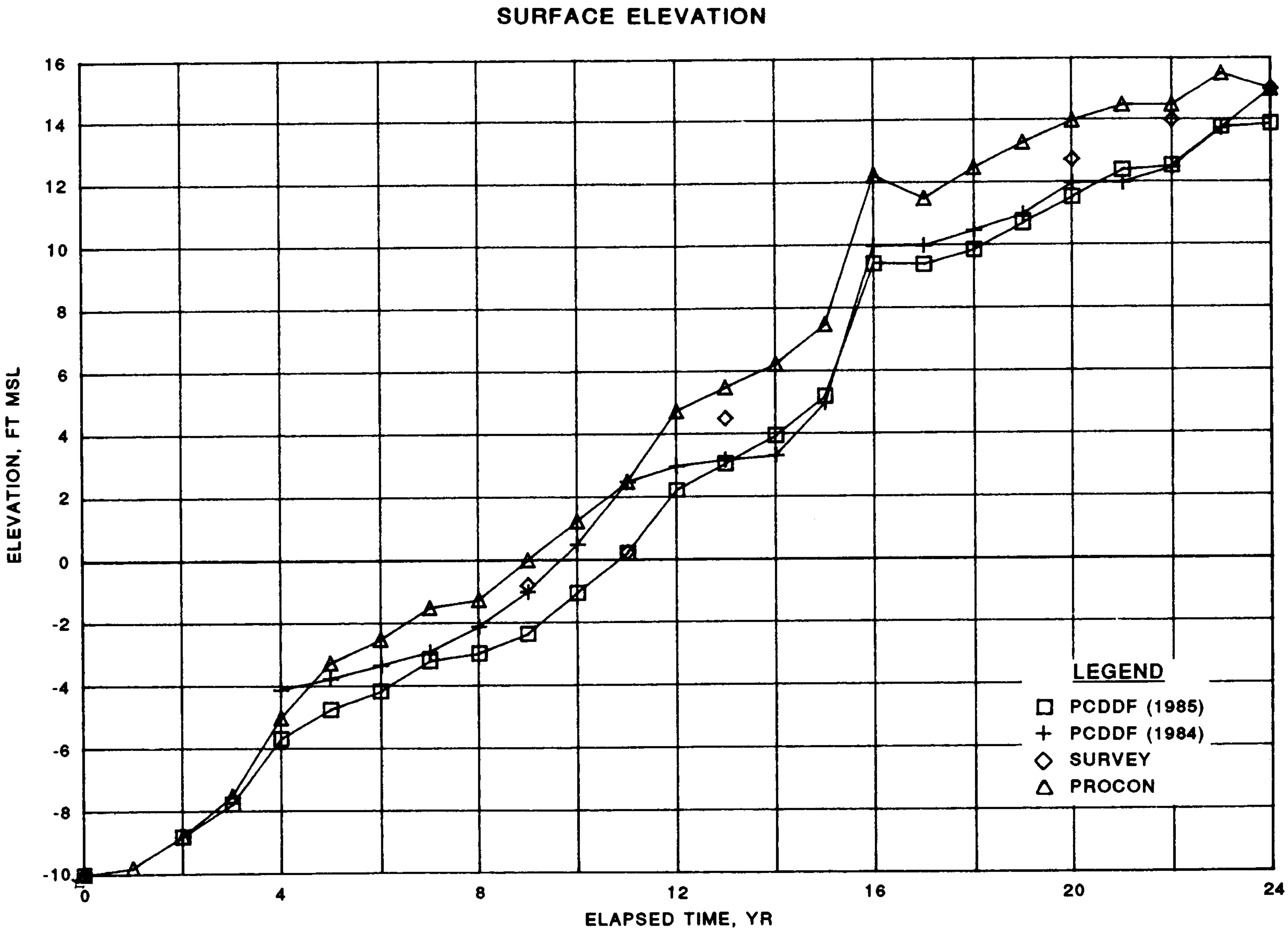

Figure C2. Comparison of verfication simulation

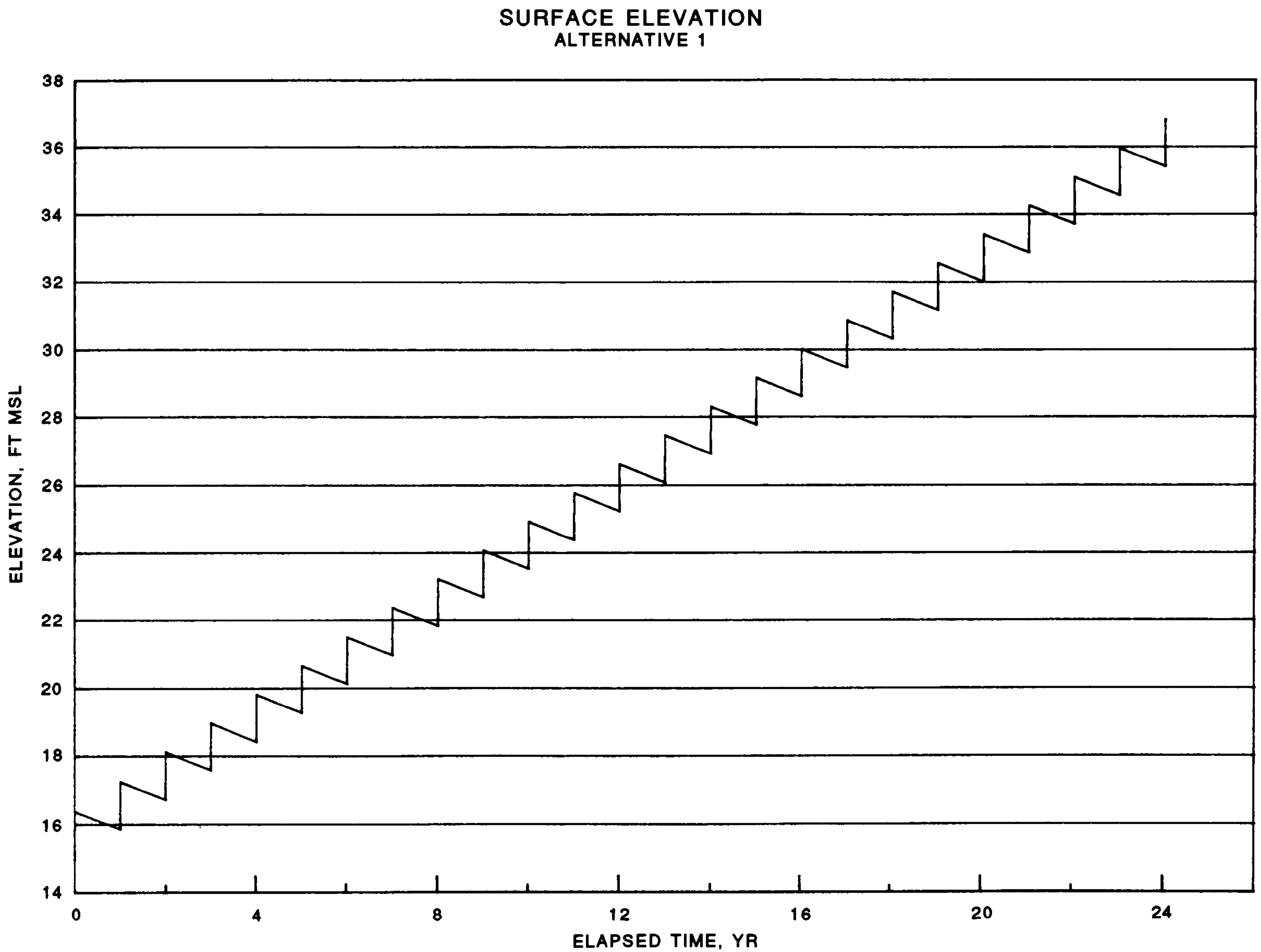

Figure C3. Surface elevation for Alternative 1

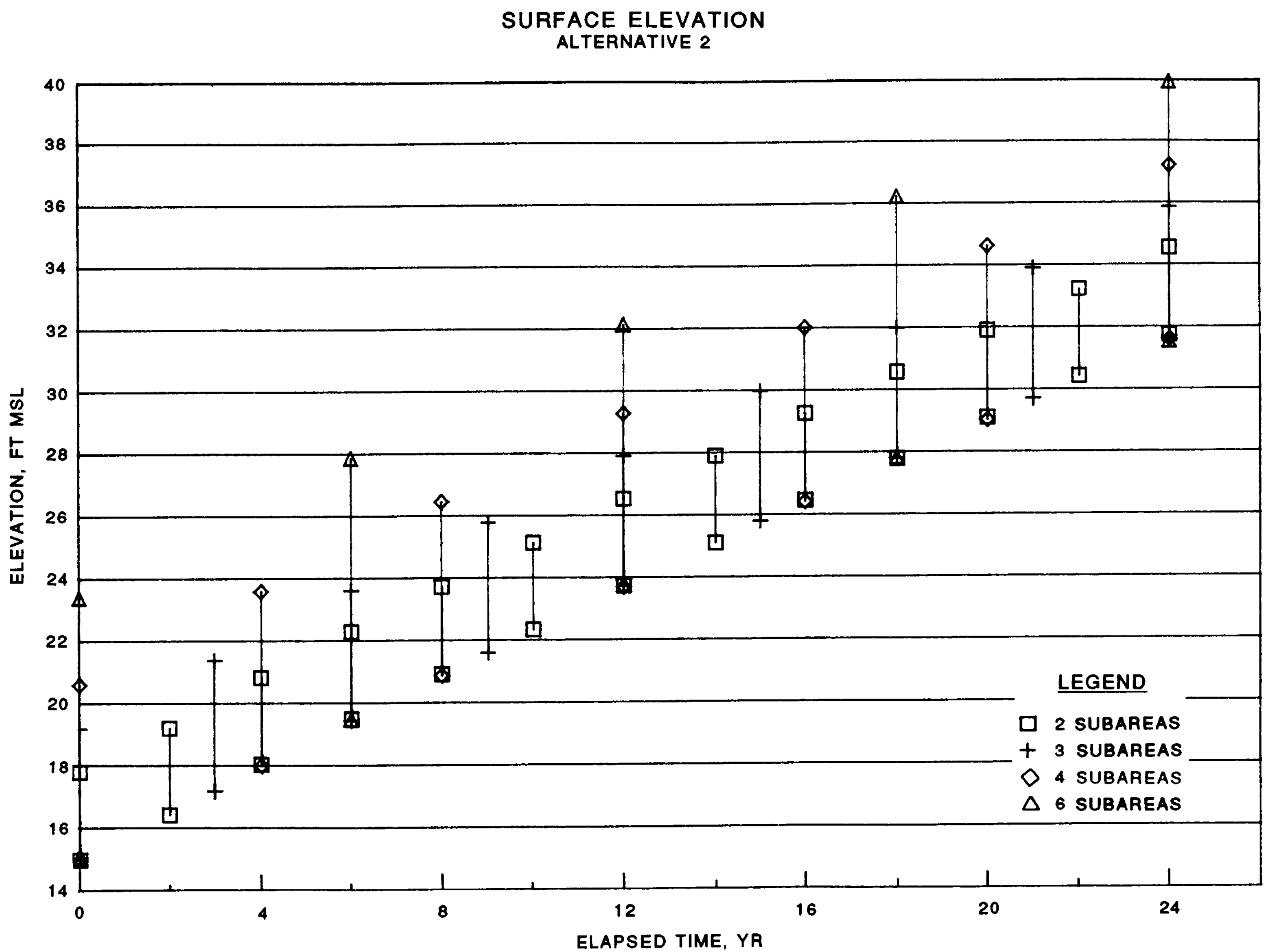

Figure C4. Surface elevation for Alternative 2

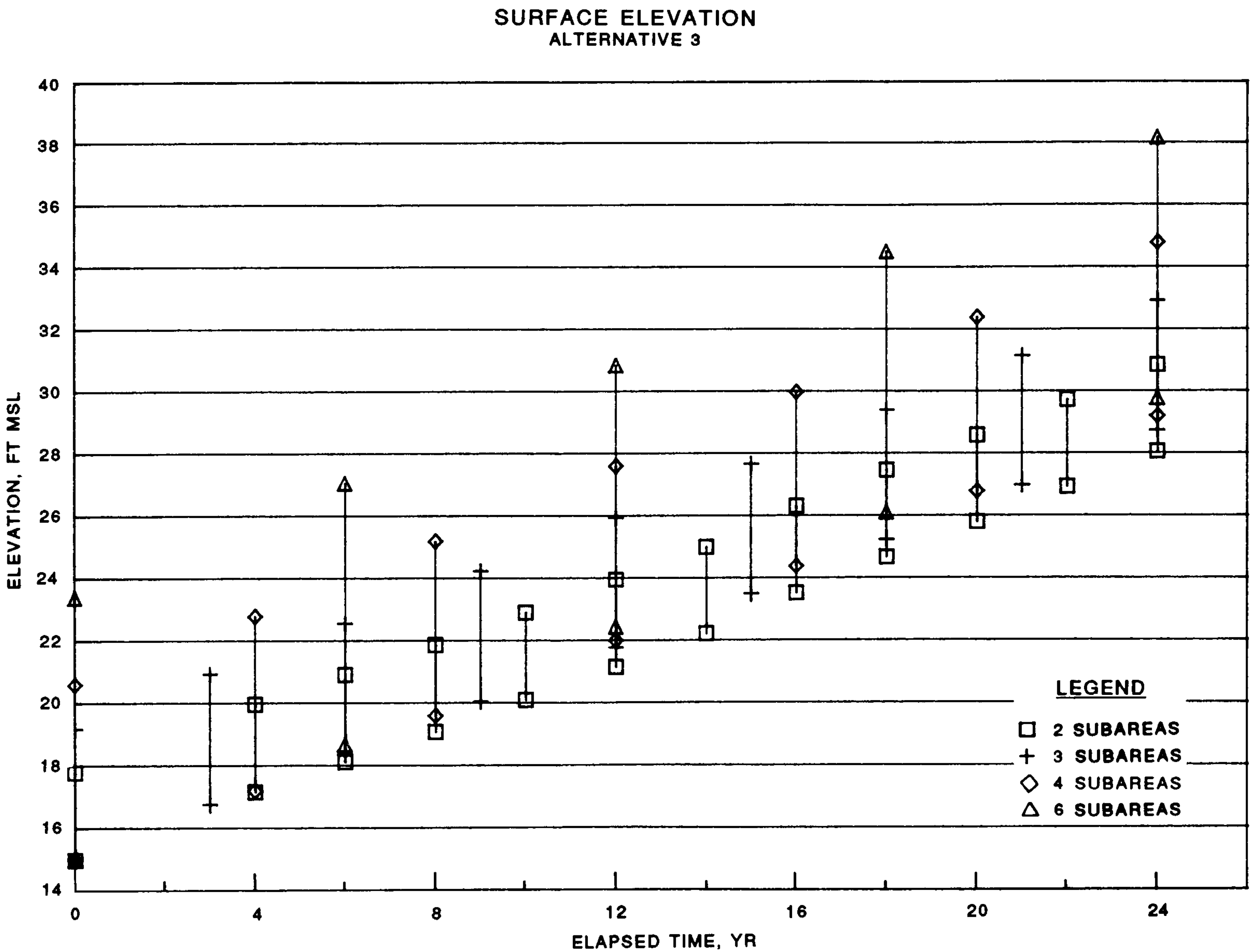

Figure C5. Surface elevation for Alternative 3

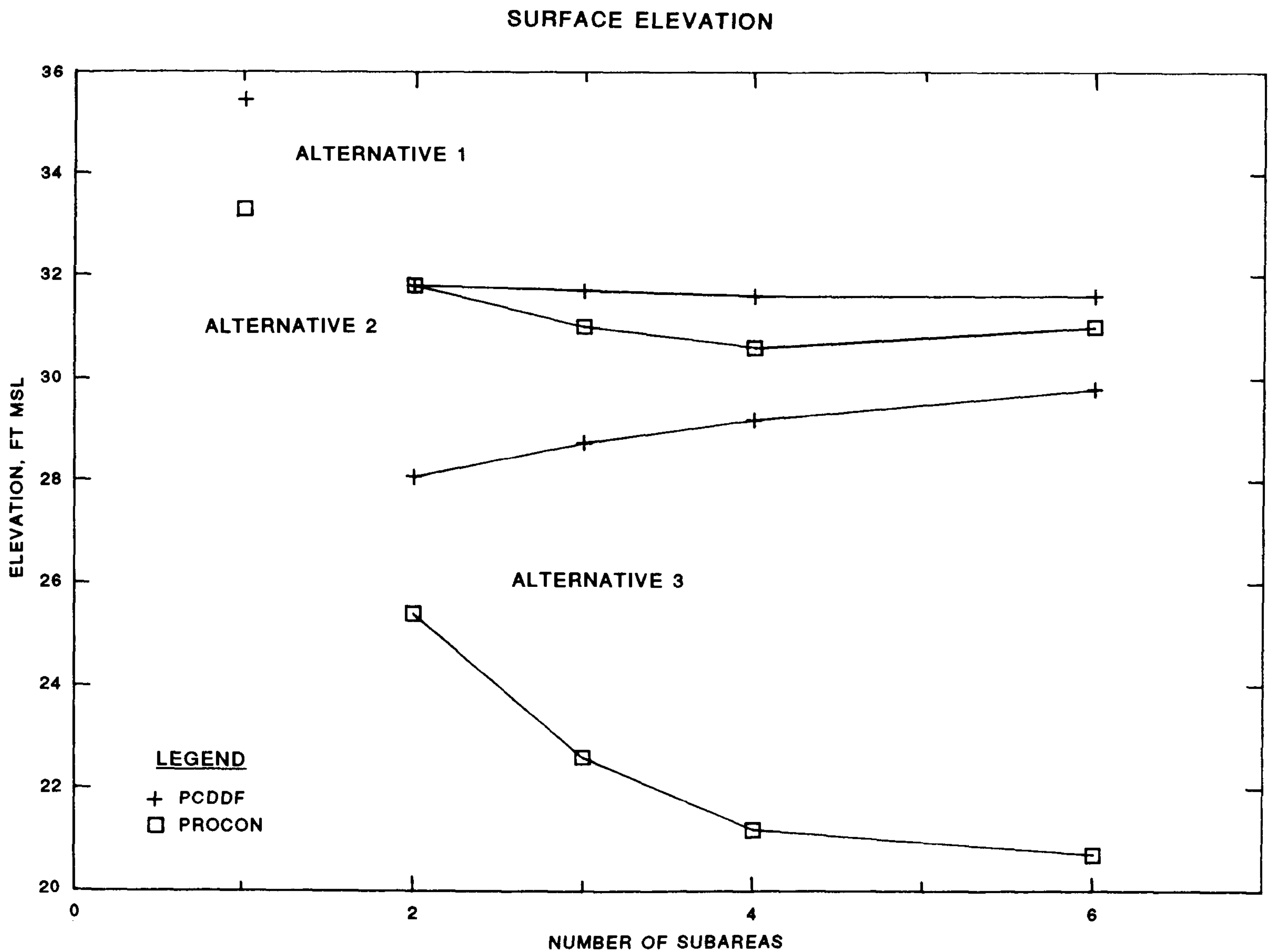

Figure C6. Comparison of PROCON and PCDDF surface elevation after 24.5 years